SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

(Including the Reports of the Imperial Dairy Expert and the Secretary, Sugar Bureau)

1922-23

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1923

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REPORT OF THE DIRECTOR.

(D. Clouston, C.I.E., M.A., D.Sc.; and W. H. Harrison, D.Sc.)

I. Charge and Staff.

Charge. Mr. S. Milligan held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to 31st May, 1923, when he proceeded on leave and Dr. D. Clouston, C.I.E., was appointed to act for him.

The post of Joint Director was held by Dr. W. H. Harrison throughout the year.

Staff. Mr. F. J. Warth, Physiological Chemist, went on 8 months' leave from 7th April, 1923, and Mr. A. V. Iyer, his First Assistant, has been acting for him.

Mr. J. H. Walton, Assistant Bacteriologist, has been granted one year's leave from 17th February, 1923. Mr. N. V. Joshi, First Assistant to the Imperial Agricultural Bacteriologist, has been appointed to officiate.

Mr. J. F. Dastur, Supernumerary Mycologist, was transferred to the Central Provinces on 13th February, 1923, and appointed to act as Mycologist of that province.

Mr. G. R. Dutt, Personal Assistant to the Imperial Entomologist, officiated from 3rd to 17th May, 1923, for Mr. P. V. Isaac, Second Entomologist (Dipterist), while he was on leave.

During the absence of Mr. G. S. Henderson, Imperial Agriculturist, on leave for 15 days in October 1922, Khan Sahib Mohamed Ikramuddin acted for him. Mr. M. Wynne Sayer, Secretary, Sugar Bureau, was appointed to act as Imperial Agriculturist, in addition to his own duties, from 3rd April, 1923, the date from which Mr. Henderson went on leave for seven months.

II. Work of the Institute.

Scientific work. The more important work of the Institute is briefly summarized below :—

Botanical Section. In the two chief wheat-growing provinces of India (the United Provinces and the Punjab), the total area under the improved varieties of wheats evolved at Pusa is now well into the second million acres, and some of them are even making headway under such widely different conditions as the Peshawar valley, North Sind, Kathiawar, the Nilgiri hills and the Southern Shan States. Of the new bearded hybrids obtained by crossing Pusa 6 with Punjab 9, Pusa 54 has emerged successfully from the preliminary field trials, and seed is now being multiplied for trial under cultivators' conditions. A detailed study of the Indian linseed crop has resulted in the isolation of unit species which give better yields than the mixtures grown on the alluvium. Seed of these promising types has been issued for field trials. Further work in connection with the investigation of a form of paralysis known as lathyrism has not obtained the slightest evidence in favour of the current view that it is due to the long continued consumption of the seeds of *khesari* (*Lathyrus sativus*). A beginning has been made with the study of the conditions necessary for seed formation in lucerne and other leguminous fodder crops.

Chemical Section. The study of the movements of nitrates in the soil and sub-soil with a view to their correlation with seasonal cropping variations was continued on the lines laid down in last year's report and absorbed a large portion of the energies of the Section. This year's observations tend to show that for the conservation of nitrates the best types of soil are those which possess a fairly heavy layer of a depth from three to four feet, and that from the point of view of nitrogen conservation the value of green-manuring during the earlier stages of the monsoon is open to question, owing to the rapidity with which the nitrate formed is carried down into the deeper layers of the soil. Further experiments on the windrowing of sugarcane confirmed the conclusion previously arrived at, that cane stored under protection remained in excellent condition, whereas that stored in the open and exposed to rain and sunshine rapidly deteriorated. The results obtained indicate the possibility of storing canes in Bihar provided suitable precautions are taken. Both pot and plot experiments laid down to determine the effect of gypsum contained in commercial superphosphates on the cropping value of Pusa soils showed that it had a clearly defined depressing effect. Work on the determination of available P_2O_5 in calcareous soils was continued. In actual practice a 1 per cent. solution of K_2CO_3 was found to be the most convenient solvent for general use.

Animal nutrition. The main problem under investigation by the Physiological Chemist is the digestibility of the more common Indian fodders. The past year's work with paddy straw gave interesting results. The average digestion co-efficients found for fibre and nitrogen-free extracts were 72 and 44, respectively. When compared with the results obtained from similar experiments carried out in America, these figures indicate that the country-bred bullocks under trial at Pusa digest 10 per cent. more organic matter than American breeds. With the transfer of the Animal Nutrition Section to the newly established Imperial Institute of Cattle-breeding and Animal Husbandry at

Bangalore, the scope of its activities will, it is hoped, be considerably developed.

Bacteriological Section. The work on nitrogen fixation in soil by non-symbiotic organisms gave important results during the year, which serve to indicate that in time it should be possible to show in what manner the cultivation of the soil may be modified so as to increase the amount and rate of nitrogen fixation naturally taking place therein. Further work on the activation of nitrification of cattle urine with a view to the conservation of its nitrogen-content was carried out and a method of doing this in the cattle-sheds of the ordinary cultivator was devised. The investigation into the solubilization of rock phosphate was carried a stage further by the use of sulphur-oxydizing bacteria; the additions of gypsum to the sulphur-phosphate compost appeared to increase solubilization by improving the physical texture of the mass with regard to aeration. Further work on vat fermentation of indigo showed that in cases where fermentation is poor, settling bad and produce low, neutralization with caustic soda before beating should result in improved settling and an increased yield of indigo.

Mycological Section. Appreciable progress was made with investigations into the diseases of paddy caused by *Piricularia*, a sclerotial fungus and a species of *Cephalosporium*. The study of the genus *Helminthosporium* on cereals was continued with special reference to the relationship between those on grasses and crop plants. Field experiments devised to test the effect of seed treatment on the prevention of smut of *bajra* (*Pennisetum typhoideum*) proved inconclusive. A further study of the foot rot of wheat indicated the possibility of reducing the loss by later sowing. Applications of sodium sulphate were found to have considerable influence in reducing the incidence of the parasite which causes the stem-rot of jute. Observations are being continued to elucidate the effect of phosphate on *rahar* (*Cajanus indicus*) and on the fungus causing wilt,

and the effect of mineral phosphate as compared with phosphate in association with organic matter in cattle and green manures.

Entomological Section. The investigation on borers in sugarcane and other gramineous plants was continued and indicated that previous work on species occurring around Pusa had been fairly thorough. Cotton plants sown in 1921 were kept under observation until uprooted in June 1923 specially to ascertain whether an abnormal shedding of bolls had any connection with the presence of certain bugs on the plants, but further research is required to make a definite statement on the subject. Investigation of fruit pests, especially *Aspidiotus perniciosus*, in Kashmir was taken up towards the close of the year and is still in progress. The Imperial Entomologist has in hand the preparation of a book dealing with the insect pests of domestic animals in India, for the use of veterinary officers and colleges, and he is also collaborating with the Director of the Muktesar Laboratory in a series of experiments on the cyclical transmission of the rinderpest organism.

Agricultural Section. The permanent experiments being carried out in collaboration with other Sections of the Institute were continued. Though the continuous heavy rainfall of the year under review resulted in an almost total failure of the monsoon crop, the produce was worth about Rs. 56,000, and a herd of over 300 head of cattle was maintained on a green fodder ration throughout the year.

During the last ten years the average daily yield per cow has nearly doubled, the improvement being most clearly marked in the Montgomery section of the herd. The cross-bred Ayrshire-Montgomery cow Alibi by name completed her fifth lactation period and gave 1,200 gallons in 300 days; many of the younger cross-bred cows which did not do brilliantly at first are showing every sign of becoming 7,000 lb. milkers. The three-quarter, one-quarter and

double cross-breds in the herd do not appear to be very promising, the effect of the heat being very noticeable in the case of the three-quarter crosses.

Imperial Dairy Expert. This officer continued to interest himself in the milk supply of large cities like Calcutta and Bombay, and prepared no less than five schemes for the western capital. No definite steps have yet been taken, however, to carry out any of these schemes. Advice was also given on schemes for opening dairy farms at Lahore, Ootacamund, Sirsa, Kamshet, Baroda and Dewas; for establishing a modern dairy college by the Government of Bombay at the Kirkee military dairy farm; for providing Jamshedpur with a reliable milk supply, and for erecting a factory for the manufacture of tinned sterilized milk, condensed milk, dried milk, etc., in the Punjab. As a result of the recommendations of the Inchcape Committee the military dairy farms at Bangalore, Wellington, and Karnal have been taken over by this department. They will be utilized as centres at which men will be trained in dairying and animal husbandry.

The Imperial Dairy Expert has done much during the year to stimulate an interest in cattle-breeding and dairying by delivering at different centres lectures illustrated by cinema films.

Sugar Bureau. Trials conducted with the selected Coimbatore cane seedlings Co 210, Co 213 and Co 214 with a view to testing the milling qualities under factory conditions have given very promising results. In carrying out these trials most valuable assistance was obtained from the firm of Messrs. Begg, Sutherland, and Company. The demand for seed of these desirable canes being now much in excess of the supply available, steps have been taken to increase the area under this crop at Pusa to 60 acres. A fresh batch of seedlings from Coimbatore is being tested with the view of ascertaining their suitability to conditions in Bihar. The sugar cable service conducted by the Bureau has proved of value in stabilizing the sugar markets in

India by preventing any panic or sudden rise due to unofficial reports and rumours from foreign countries.

Training. Eleven post-graduate students were under training at the Institute during the year in the following subjects :—

General Agriculture	3
Economic Botany	1
Mycology	2
Economic Entomology	1
Agricultural Bacteriology	4
	11

In addition to these, twelve students joined the Institute for shorter courses of instruction.

With the object of developing the post-graduate training at Pusa to the highest possible standard, a scheme for the expansion of the Institute as regards staff was sanctioned by the Secretary of State in 1921; but the depressed condition of Imperial finances has made its immediate realization impossible. The Government of India have, therefore, decided to utilize in the meantime the facilities already available at the Institute, and to start from the 1st of November 1923 post-graduate courses in agricultural chemistry, botany, mycology, bacteriology and entomology to qualify for Imperial appointments in the Agricultural Service. The period of each course will be two years. As a start it is proposed to admit 12 students, *viz.*, 3 in agricultural chemistry, 2 in mycology, 2 in entomology, 3 in agricultural bacteriology and 2 in botany.

As regards the training of Deputy Directors of Agriculture and Professors of Agriculture, the Government of India have decided to begin with a course in animal husbandry and dairying. This will be given at the Imperial Dairy Institute, Bangalore, and at Pusa. The course will last for 15 months and will be confined for the present to officers of the Provincial Service who have put in at least two years' service.

III. Publications.

Nineteen Memoirs, fourteen Bulletins, one Indigo Publication and six other publications were issued during the year, while over 15 publications were in the press on 30th June, 1923.

Bulletin No. 28 on "Lac cultivation in the Plains of India," of which two editions had already been sold out, was brought up to date and issued as Bulletin No. 142 which is practically a new publication. To meet the constant demand for Bulletin No. 46 on Bee-keeping a second edition has been sent to the press. Mention also may be made of the "Report on the Diseases of Silkworms in India" issued during the year; it embodies the results of the researches of the Protozoologist, Dr. Pringle Jameson.

"The Agricultural Journal of India," which is issued every two months, continues to maintain its popularity among the class of readers for which it is meant.

IV. Accounts.

The total expenditure during the financial year ending 31st March, 1923, as shown below, was Rs. 7,86,056 as against Rs. 7,81,034 during the previous year.

	Rs.
General expenditure of the Institute, including the Agricultural Adviser's Office	2,81,095
Botanical Section	65,265
Chemical Section	61,514
Physiological Chemical Section	38,277
Bacteriological Section	67,385
Mycological Section	62,732
Entomological Section	52,156
Pathological Entomological Section	21,213
Agricultural Section	1,29,635
Indigo Research Section (closed from 20th May, 1922)	6,784
Total	7,86,056

The following are the principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser for expenditure on special agricultural experiments :—

	Rs.
Purchase of a sledge sorter	828
Experiments with fibre extracting plant . .	731
Mosquito experiments	379
Purchase of tanks, pipes, etc., for irrigation work at Pusa	3,861

The gross receipts during the year from sale of publications, farm produce, milk and other articles amounted to Rs. 45,852 as against Rs. 38,822 last year.

V. Conference.

The fifth biennial meeting of Entomologists was held at Pusa from 5th to 10th February, 1923, and was attended by 45 members, the visitors including delegates from the United Provinces, Bihar, Mysore, Kashmir, Gwalior, Ceylon, the Forest Research Institute at Dehra Dun, the Central Research Institute at Kasauli and the Imperial Bacteriological Laboratory at Muktesar. The proceedings of the meeting, which run to about 400 pages, are in the press.

REPORT OF THE IMPERIAL ECONOMIC BOTANISTS.

(A. Howard, C.I.E., and G. L. C. Howard, M.A.)

I. Introduction.

The Imperial Economic Botanist held charge of the Section during the year ending June 30th, 1923. As far as funds permitted, a number of improvements were carried out in the Botanical Section chiefly with the object of increasing the efficiency of the local labour. Three meetings of the Central Cotton Committee were attended and some time was devoted to the Lucknow meeting of the Indian Science Congress.

The work of the staff generally continues to be satisfactory and Haji Abdur Rahman Khan and Babu Kashi Ram deserve special mention.

II. General Seed Distribution.

During the year, a return of the seed distributed by the Pusa Research Institute was prepared. The selected seed given out by the Botanical Section between 1910, when distribution started, and 1922, both inclusive, was sufficient to sow 263,063 acres. This includes the wheat grown under our supervision, on various estates in Bihar, between the years 1914 and 1919 before the seed farms in the Provinces (established by a special grant from the Government of India) were in working order. The details of this distribution are given in Table I.

TABLE I.

Seed distributed by the Botanical Section, Pusa, from 1910 to 1922.

Year	Wheat	Wheat (Bihar estates)	Tobacco	Gram	Fibre plants
1910 . .	15	..	..	..	..
1911 . .	81	..	..	..	..
1912 . .	206	..	..	6	..
1913 . .	45	..	190	4	..
1914 . .	13	1,607	60	8	..
1915 . .	11	2,491	1,800	..	9
1916 . .	121	8,030	17,450	42	20
1917 . .	86	6,115	17,160	8	8
1918 . .	16	5,134	24,900	24	8
1919 . .	144	3,119	26,870	13	17
1920 . .	158	..	17,210	16	2
1921 . .	285	..	60,000	57	13
1922 . .	171	..	69,300	18	2
TOTAL (IN ACRES)	1,352	26,496	234,940	196	79

III. WHEAT.

Seed distribution. In recent reports, an account has been given of the methods employed and the stage reached in the intensive distribution of improved wheats in one of the chief wheat growing Provinces of India. In the United Provinces, the dissemination of Pusa 12 and Pusa 4 has now reached a stage when it is no longer possible to state the area actually sown by the cultivators. In 1921 it was estimated at over 400,000 acres. Every year, the Provincial Department distributes 30,000 maunds of fresh seed while the natural spread of these varieties by the people themselves is known to be considerable. In the Punjab in 1921-22, the area under Punjab 11, a variety with white grain selected by this Section in 1908, reached 750,000

acres. This occurs chiefly in the Lower Chenab and Lower Bari Doab Canal Colonies. During a recent tour in the latter just before the harvest of 1923, vast stretches of this wheat—a bearded type with bronze coloured chaff—were seen practically true to type and with little or no admixture of any kind. Similar areas of Pusa 12 are now exceedingly common in various parts of the United Provinces. This circumstance is of considerable promise for the future progress of agricultural India as it is the first step towards the establishment of definite grades of wheat for internal consumption and for the export trade. *The total area under improved wheats, in the United Provinces and the Punjab, is now well into the second million acres and moreover is steadily increasing year by year. At a moderate estimate, the annual increased profit to the growers can be placed at fifteen rupees an acre.*

Outside the United Provinces and the Punjab, a number of other important wheat growing areas occur in India in which field trials of Pusa wheats have been in progress for some time. The original object of these tests was to find out what varieties are needed in the various tracts rather than the initiation of schemes of seed distribution. The results which have been obtained recall the parable of the sower. While a good deal of the seed has fallen by the way side and on stony ground, nevertheless some has found its way to good soil. Not only has the information desired been obtained but a number of promising seed distribution schemes have also begun. Some of the results obtained have been altogether unexpected. For example in the North-West Frontier Province, a sample of Pusa 4 was sent some years ago to an Agricultural Exhibition at the Tarnab farm chiefly for the purpose of showing the cultivators what a really high quality white wheat looks like and what can be produced in India. This variety was duly tried and proved to be rust resistant and to possess excellent standing power when grown under cultivators' conditions. In the short space of seven years from the date of its first distribution, Pusa 4 has almost entirely displaced the local wheat in the

Peshawar District and it is estimated that the new variety was sown on 150,000 acres in 1921-22. The Agricultural Officer, North-West Frontier Province, states that one acre of Pusa 4 is worth from ten to fifteen rupees an acre more than that of the same area of any local wheat. The fact that this shallow-rooted, rapidly growing variety does so well in the Peshawar valley, where the growth period is a comparatively long one, would appear to indicate that the sub-soil conditions there are not suitable for root development and that deep-rooting, heavy yielding types are not likely to succeed. Since these results were obtained, Pusa 4 has been tried successfully in the low-lying *bet* areas alongside some of the Punjab rivers where the sub-soil water is quite close to the surface. For all similar tracts in India, this variety seems well worth extended trial.

For some years past, Pusa 12 has been grown in parts of Sind chiefly in the Sukkur *taluqa* and on the North Sind Frontier near Jacobabad. This variety does well when grown by the cultivators and Mr. Main proposes to undertake a definite scheme of seed distribution. As this type is able to mature a crop with comparatively little water, it should prove of great value when the maximum duty of canal water comes to be worked out in connection with the Lloyd barrage at Sukkur. In this portion of the valley of the Indus, where the soils are stiff and the sub-soil water is comparatively near the surface, it will probably be found to be an advantage to raise crops on the lowest possible amount of water (so as to preserve the natural fertility of the soil) rather than adopt a more intensive method of irrigation. If this proves to be the case, varieties like Pusa 12 will at once come into their own.

In the Eastern Punjab, a certain amount of unofficial distribution of Pusa 12 has been undertaken by the cultivators themselves. A recent tour in this region, just before harvest, disclosed the fact that the area under this wheat is much larger and the crop is much more uniform and true to type than was to be expected. In the Simla Hills, thanks to the interest of Mr. H. E. J. Peake, the Manager

of Solon Brewery, Pusa 12 is spreading rapidly in the various Hill States and appears to be thoroughly at home in the terraced cultivation of this region.

In Bihar and Orissa, the Province in which Pusa is situated, the area under improved wheats is increasing in the Patna Circle where the outturn and market rate of Pusa 12 is higher than that of the local wheat. In the flooded rice areas in Orissa, where the paddy crop is often completely destroyed, Pusa 4 is proving successful as a late sown cold weather catch crop and a scheme of seed distribution is being started. In the damp soils of the Tirhut Division in North Bihar, where an early, rust resistant wheat of high quality is desirable, excellent results have been obtained with Pusa 6 under experiment station conditions but this type has proved unsuitable for distribution as it sheds its grain if allowed to ripen fully and is also liable to lodge, particularly under intensive cultivation. These defects have now been removed by hybridization, using Pusa 6 as one of the parents. Three new types—Pusa 52, 53 and 80—have been fixed, tested in the field and found to be suitable for this tract. So far, Pusa 53 has given the best results at Pusa. Sufficient seed of this variety will be available next March for preliminary trials in the region north of the Ganges between the Gandak and the Kosi

In Bengal, Pusa 4 and Pusa 12 have given good results in the Burdwan and Rajshahi Divisions. They have also done better than the local wheat at Murshidabad under irrigation. It is hoped to distribute these varieties on a large scale this year.

In the Central Provinces, Pusa 100 (obtained from the progeny of a cross between Mozaffarnagar and one of the local Bihar wheats) is doing well in the Chattisgarh and Nagpur Divisions. When grown under ordinary conditions it can be relied on to give an increase of 100 lb. of grain to the acre above the yield of the local *durum* wheats.

With the exception of Bundelkhand and the Central Provinces, no large schemes of distribution of Pusa wheats

have so far been undertaken on the black soils of Peninsular India. A number of trials have, however, been undertaken and very valuable results have been obtained. Under well irrigation, particularly with intensive cultivation, Pusa 4 gives exceedingly high yields on black soils like those of the Malwa plateau. Where the problem is to raise the largest possible crop on the smallest area of these soils, this variety is exactly what is required. It is useless, however, as a *barani* wheat on the black soils. In Baroda and Kathiawar, Pusa 12 has done well at a number of the local farms but up to the present little has been done in the way of systematic seed distribution. In the Jaipur State, Thakur Kalyan Singh, the Chief of Khachariawas, has taken up the cultivation of Pusa 12 with enthusiasm and success. The Court of Wards in one of the neighbouring States is doing similar work.

In the Nilgiri hills in Madras, a number of Europeans have been experimenting with Pusa wheats and have reported good results. The local Agricultural Department is now interesting itself in this subject and will no doubt help in the distribution of that variety which proves most suited to the local conditions.

In Burma, Mr. McKerral reports that Pusa 4 has done very well in the Southern Shan States and that the Imperial Institute has reported that the quality of the grain produced there is equal to that of the best Manitoba wheat. When the railway, now under construction, is completed, the valleys of the Southern Shan States will be able to grow large quantities of high quality grain and a new wheat producing area will be added to the Empire.

One aspect of these wheat trials needs to be emphasized, namely, the fact that it has been possible at one central station to produce varieties of wheat suitable for such widely different conditions as the Peshawar valley, North Sind, Kathiawar, the Nilgiri hills, the Southern Shan States as well as the various tracts included in the pentagon formed by joining these five points. This figure includes practically the whole of the wheat growing areas of the

Indian Empire. It is often argued that the soil and climatic conditions of the various regions producing any particular crop even in one Province are so different that the results obtained in any tract cannot possibly apply to the others and that a plant breeding station in each is a necessity. Apart from the great expense entailed, a number of other considerations point to the advantage of maintaining the smallest possible number of well-equipped plant breeding stations in India rather than conducting the work in piece-meal fashion. With one central station a few improved varieties have to be dealt with, seed distribution schemes can be founded on a broad basis, the trade and the public are not bewildered by a constant flood of new creations whose existence is often transient and the road is opened to the ultimate establishment of a few definite grades of produce over large areas. The energies of the Agricultural Department can then be concentrated on the maintenance of the improvement achieved and on increasing and consolidating the area under the new types. In this way, a real step forward in the uplifting of agricultural India can be achieved with the means already available.

The amount of selected seed distributed by the Botanical Section during the year under report was 163 maunds which was sent to 141 correspondents. As in previous years, most of the indents received had to be cut down considerably while a number could not be complied with at all.

Bearded wheats. In some localities where the crop is liable to damage by animals and birds, there is an insistent demand for an improved bearded wheat. To meet this, a series of bearded varieties have been obtained from Pusa 6 and Punjab Type 9 by means of hybridization. These are now being subjected to field trials at a number of stations in the United Provinces, the Punjab and Sind where the soil conditions are more suitable for such work than those which obtain at Pusa. Pusa 54 has emerged successfully from the preliminary trials on the farms in the

Central Circle of the United Provinces and seed is being multiplied by Mr. Low at Kalianpur for trial under cultivators' conditions. Samples of five of these bearded varieties have been sent to Mr. Humphries in England for complete milling and baking tests.

International Congress of Agriculture. A paper on the improvement of Indian wheat was contributed to the International Congress of Agriculture which meets in Paris during the current year.

IV. Other Crops.

Tobacco. The demand for seed of Pusa 28 continues. During the year, nearly 14½ maunds of selected seed was supplied to 39 applicants. The breeding work on this crop is being written up and will soon be ready for the press.

Fibres. Nearly a maund of seed of *Hibiscus cannabinus*, Type 3, was distributed in small lots to 22 applicants. The breeding work on Roselle, which has been in progress for some time, is being prepared for publication.

Oil seeds. For some years a detailed study of the unit species of the Indian linseed crop has been in progress at Pusa, the results of which were sent in for publication during the year and will shortly appear in the Botanical Series of the Memoirs of the Imperial Department of Agriculture in India. This work has yielded important results both from the scientific and practical points of view. A number of the unit species, isolated from the mixtures grown on the alluvium, yield about forty per cent. more than the ordinary mixed crop. Nearly five maunds of seed of these promising types has been issued for preliminary field trials to a number of correspondents in the plains. The unit species suitable for the black soils of Peninsular India are being tested by the Agricultural Department of the Central Provinces.

Gram. The unit species of this crop, which were isolated some years ago, were maintained in pure culture and a supply of seed of the more promising types was main-

tained. Twenty-four maunds of seed was issued to 44 applicants. During recent tours in the United Provinces it was found that Type 17 was doing very well at all the farms visited. No large schemes of seed distribution have yet been undertaken. It is expected, however, that the distribution of this variety to the cultivators will be one of the many beneficial results of the formation of the new Rohilkhand Circle.

Khesari (*Lathyrus sativus* L.). In connection with the investigation of lathyrism, the unit species of this crop are being separated and classified. The root development is also being worked out.

V. Indian Science Congress.

A good deal of time was devoted to the meeting of the Indian Science Congress held at Lucknow in January of this year at which the Second Imperial Economic Botanist was President of the Botany Section and of the joint meeting of the Sections of Agriculture and Botany when the improvement of fodder and forage in India was discussed. Forty-seven papers were sent in for the Botany Section and eighteen for the fodder discussion. Besides the Presidential address to the Botany Section on the rôle of plant physiology in agriculture, five other papers were read by us at the Congress—one on lathyrism (with Captain Anderson, I.M.S., and Dr. Simonsen) before the Medical Section; one on the theory of phosphatic depletion in the soils of Bihar before the Agricultural Section; one on the improvement of lucerne cultivation in connection with the joint meeting on fodder and two (on the development of intensive cultivation in India and on the leguminous crop in the rotation) before the symposium on the nitrogen problem in Indian agriculture which was arranged by the Sections of Chemistry, Agriculture and Botany. In previous meetings of the Science Congress no combined meetings have been arranged. The new departure was a great success and the joint meetings were well attended.

Discussions in which unofficial workers and investigators from different Government departments can take part often reach a high level and lead to useful developments. The eighteen papers contributed to the fodder discussion are being printed as Bulletin No. 150 of the Pusa Institute. The authorities of the Science Congress have decided to publish, in permanent form, a scientific account of the nitrogen symposium and to distribute a large number of reprints to workers in India and other countries interested in this important subject.

VI. Physiological Investigations.

A full account of the physiological investigations in progress was given in the previous report to which the reader interested in these questions is referred for details.

Soil aeration. In the study of the soil aeration factor in the case of plants grown in Pusa soil in lysimeters with free drainage, it has frequently been observed that in years of normal rainfall a decided falling off in permeability takes place after July. The soil refuses to drain, the pore spaces in the surface soil become suffused with water, aeration falls off and the absorbing roots die. Java indigo, for example, maintains itself during the late rains entirely by means of the surface roots and those which occur in the drainage layer on the floor of the lysimeter. This state of affairs appears to be associated with the formation of colloids in the soil and is always accentuated when the supply of organic matter needs renewal. It occurred to us that the real explanation of the effect of small dressings of superphosphate in the late rains may really be due to the effect of this weak acid on the colloids. If so, any other weak acid or substances like sulphur which are readily oxidised in the soil, would probably produce similar results. The matter was put to the test of experiment; the plant selected was cotton which is known to be exceedingly sensitive to poor soil aeration. The results are given in Table II and show that both dilute sulphuric acid and sulphur gave better results than superphosphate.

TABLE II.

The effect of "dilute acids" on the growth of cotton.

	Average height of 20 plants in cm.	Weight of green plants in grammes	REMARKS
Superphosphate	49·1	855	Manures added at the rate of one maund per acre.
Flowers of sulphur . . .	65·7	1,653	
Dilute sulphuric acid . . .	58·9	1,453	

Field experiments are now in progress in which the effect of sulphur and superphosphate on green manuring with *sanai* (*Crotalaria juncea* L.) are being compared.

The effect of grass on trees. The results obtained on this subject during 1923, a year of short rainfall, confirm those obtained in 1921 in which the monsoon was far below the average. A mass of material has accumulated on this subject which is now being studied. It is hoped to have it ready for the press shortly and to discuss the results in next year's report.

Root development. Observations on the root development of maize and *juar* (*Andropogon Sorghum*) have now been repeated for the third year in succession. The results are very concordant and are being prepared for publication.

Leguminous crops. Some of the results obtained on the effect of nitrogenous manures on the growth of leguminous crops will appear shortly among the papers contributed to the symposium on the nitrogen problem in Indian agriculture.

A beginning has been made (by Babu Ilabonto Banerji, a research student in the Section) in the study of the conditions necessary for seed formation in lucerne and other leguminous fodder crops. Until an indigenous seed supply of lucerne and berseem can be organized in India, the introduction of these valuable fodders into the general rural economy must be delayed.

Lathyrism. Under the auspices of the Indian Research Fund Association, a detailed investigation of a form of paralysis known as lathyrism—commonly supposed to be due to the long continued consumption of the seed of *khesari* (*Lathyrus sativus* L.)—is now in progress. The chemical work is in the hands of Dr. Simonsen, Forest Chemist at Dehra Dun; Captain Anderson, I.M.S., of the Central Research Institute, Kasauli, has undertaken the medical aspects of the investigation, while the botanical work has been entrusted to one of us. The earlier results obtained on this investigation appeared in a joint paper in *The Indian Journal of Medical Research* (Vol. X, No. 3, Jan. 1923, p. 857), and a stimulating discussion took place in the Medical Section of the Indian Science Congress at Lucknow. Since that date, further important results have been obtained which it is hoped to publish before the end of the year. So far, neither Captain Anderson nor Dr. Simonsen have obtained the slightest evidence in favour of the current view that the seeds of *khesari* are responsible for lathyrism. The various leguminous weeds, which occur mixed with *khesari,* have been identified and grown in pure culture and are now being studied. A large amount of botanically pure seed is available for the work which is being pushed forward as rapidly as possible. Fortunately this investigation escaped retrenchment and funds have been provided by the Research Fund Association for the work in progress at Kasauli.

VII. Programme and Publications.

Programme, 1923-24. Investigations, on the lines indicated in the annual reports and in the publications of the Section, will be continued on the following crops—cereals, tobacco, fibre plants, pulses, oil seeds, fodder crops and fruit—and on soil aeration and root development.

Publications. An effort is being made to work up the large mass of unpublished material which has been accumulating for some years and to prepare it for the press. It is hoped to complete this task before the end of 1923.

The following papers were either printed or accepted for publication during the year under review :—

1. Report on Economic Botany for the Board of Scientific Advice, 1921-22.

2. The improvement of Indian wheat—a paper contributed to the International Congress of Agriculture, Paris, 1923.

3. A preliminary note on the theory of phosphatic depletion in the soils of Bihar, *Agri. Jour. of India*, XVIII, 1923, p. 148.

4. The rôle of plant physiology in agriculture (Presidential address, Botany Section, Indian Science Congress, 1923), *Agri. Jour. of India*, XVIII, 1923, p. 204.

5. Studies in Indian oil seeds. No. 2. Linseed (*Linum usitatissimum* L.)—with Haji Abdur Rahman Khan. *Mem. of the Dept. of Agri. in India* (*Botanical Series*), Vol. XII, No. 4, 1923 (*in the press*).

6. An improved method of lucerne cultivation (included in *Bulletin 150, Agri. Research Inst., Pusa*, 1923—*in the press*).

7. The development of intensive cultivation in India (included in the symposium on the nitrogen problem in Indian agriculture published by the Indian Science Congress).

8. The leguminous crop in the rotation (included in the symposium on the nitrogen problem in Indian agriculture published by the Indian Science Congress).

9. Work done by the Botanical Section, Pusa, from May 1905 to January 1923 (printed privately).

10. A preliminary note on lathyrism (with Dr. Simonsen and Captain Anderson, I.M.S.), *The Indian Journal of Medical Research*, X, 1923, p. 857.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(W. H. Harrison, D.Sc.)

I. Administration.

The Imperial Agricultural Chemist was in charge of the Section during the whole of the period under review.

II. Education.

Mr. Sanyasi Raju, a student of the Bacteriological Section, received a short training for three months in selected methods of chemical analysis.

III. Meteorology and Drain-gauges.

The usual meteorological and drain-gauge observations were maintained. The recording hygrometer proved so satisfactory that for the future it has been decided to discontinue the records of the wet and dry bulbs hygrometer and to confine temperature records to those of the normal instrument only.

IV. General analytical work and assistance given to other Sections.

A. The following samples were analysed and reported upon :—

Soils	6
Manures	22
Feeding stuffs	6
Sugarcane	32
Sugar-beet	23
Milk	944
Water	4
Oils	4
Dyes and tanning materials	4
Miscellaneous	38
Total	1,083

The samples of sugar-beet were analysed at the request of the Agricultural Officer, North-West Frontier Province.

One sample of manure and one sample of water were received from Hyderabad State, the dyes and tanning materials from the Principal, Technical Institute, Cawnpore, and samples of pears and perry from the Manager, Solon Brewery.

B. The following assistance was rendered to other Sections :—

Agricultural Section. Eleven samples of manures, two of feeding stuffs and 944 of milk were reported upon.

Botanical Section. One sample of soil was analysed.

Mycological Section. One sample of soil and two of sugarcane were examined. In addition, assistance was given with analytical work during the initial stages of certain research work initiated in this Section.

Fibre Expert. A sample of the alkaline extract of the sunn-hemp plant was examined for various constituents and reported upon.

Sugar Bureau. Reports upon six samples of manures and 32 of sugarcane juice were submitted.

Imperial Dairy Expert. A sample of cotton-seed cake was examined.

V. Methods of Analysis.

Denige's method of estimating small amounts of phosphates (*Analyst*, 1921, 24) has been tested during the year. The method is a convenient colorimetric one, depending upon the depth of the blue colour which develops in the presence of acid ammonium molybdate and stannous chloride. It has been observed that some ten minutes must elapse after the addition of the reagents before the full colour is developed and further that this colour begins to fade at the end of half an hour. On standing for a further period haziness develops. Within these limitations the method appears to be a convenient and useful one for the estima-

tion of very small amounts of phosphoric acid, and consequently its employment in conjunction with standard coloured glasses is being studied.

In connection with the estimation of the available P_2O_5 of calcareous soils interesting results have been obtained by the use of alkaline carbonates in the extracting solution in place of the usual citric acid. These experiments will, however, be reviewed in some detail in the section of this report dealing with research and investigation.

VI. Research and Investigations.

The windrowing of sugarcane. The experiments in this direction have been continued by Mr. Sanyal. All the experimental results obtained in previous years, whether at Pusa or in the North-West Frontier Province, have led to the conclusion that the period of time during which windrowed cane can be safely stored is determined mainly by the incidence of fairly heavy rain. In order to test this conclusion in a more rigorous manner a stand of cane (Co 213) from a $\frac{1}{32}$ acre plot was lifted on January 9th, 1923, and divided into two equal portions. One portion was stored in the open and exposed fully to climatic variations, whereas the other portion was stored under shade and thus protected from rain and the direct rays of the sun. On February 1st the cane from another equal plot of land was lifted and treated similarly. Analyses were made of these windrowed canes at intervals, and a brief summary of results obtained is given in the following table :—

Date	No. of days windrowed	Windrowed in open				Windrowed under shade			
		Brix Cor.	% Sucrose	% Glucose	Purity	Brix Cor.	% Sucrose	% Glucose	Purity
9-I-23 . .	0	17·64	15·09	0·84	85·6	17·64	15·09	0·84	85·6
16-I-23 . .	7	18·69	15·25	1·66	81·6	17·63	15·40	0·59	87·4
1-II-23 . .	23	19·37	15·17	2·38	78·3	17·85	14·51	1·33	81·3
12-II-23 . .	34	20·64	14·88	3·83	72·1	19·00	15·51	1·50	81·7
17-II-23 . .	39	20·57	14·88	3·17	72·4	18·63	15·62	1·26	83·9
24-II-23 . .	46	18·75	13·03	3·58	69·5	20·37	15·37	2·50	75·47

Date	No. of days windrowed	Windrowed in open				Windrowed under shade			
		Brix Cor.	% Sucrose	% Glucose	Purity	Brix Cor.	% Sucrose	% Glucose	Purity
		Canes windrowed on 1st February, 1923.							
1-II-23 . .	0	18·56	16·71	0·60	90·0	18·56	16·71	0·60	90·0
7-II-23 . .	6	18·64	15·56	1·69	83·5	19·78	17·27	0·96	87·3
12-II-23 . .	11	19·29	15·69	3·31	81·3	19·55	16·49	0·60	84·3
17-II-23 . .	16	19·29	15·18	2·11	78·7	19·18	16·92	0·54	88·2
24-III-23 . .	51	20·67	14·60	4·21	70·6	20·53	17·42	1·54	84·9

The rainfall experienced during the course of the windrowing was :—

		Inches
January	22nd, 1923	0·01
,,	23rd ,, ...	0·02
February	11th ,, ...	0·11
,,	16th ,, ...	0·28
,,	17th ,, ...	0·32
,,	24th ,, ...	1·82

A comparison of the results obtained clearly shows that the cane stored under protection remained in excellent condition, whereas that stored in the open and exposed to climatic influence rapidly deteriorated. This year's work therefore confirms the conclusions previously arrived at and demonstrates the possibility of storing cane in Bihar by windrowing, provided suitable precautions are taken.

In conjunction with this investigation a study has been made regarding the nature of the enzymes inducing deterioration of windrowed canes and the mechanism through which their activities become effective. It has been found that these enzymes are localized in certain portions of the cane, particularly in the nodes, and normally do not affect the juice contained in the internodes. The effect of rain in contact with a somewhat dry windrowed cane is to bring about a translocation of these enzymes into the internodes and thus induce deterioration. These results are being prepared for publication.

Sugar-beet. In collaboration with the Agricultural Officer, North-West Frontier Province, Mr. Sanyal has carried out an investigation into the effect of (*a*) irrigation, (*b*) storage of mature roots in pits, and (*c*) seeding of mature roots, on the quality and quantity of the juice. It is understood that these results are being compiled for publication.

The "available" phosphate of calcareous soils. Dr. Sen some years ago showed that incremental additions of $CaCO_3$ to a soil rich in available phosphate resulted in decreased extraction by Dyer's citric acid method. Mr. Das has repeated these experiments in greater detail and has been able to show that the composition of the solvent varies with the amount of $CaCO_3$ present and that the amount of P_2O_5 extracted depends upon the composition of the solution. Dyer's method applied to soils of this type is in effect an extraction by solvents of varied composition and is unreliable.

Starting from this conclusion, the endeavour has been to discover a solvent which, whilst extracting an appreciable amount of P_2O_5, is still not naturally affected by the presence of varying amounts of $CaCO_3$, and in this connection Mr. Das has studied a large number of solvents of divergent character in their action on Kalianpur soil mixed with incremental amounts of $CaCO_3$, but in the vast majority of cases it was found that this substance exerted a marked depressing effect upon the amount of P_2O_5 extracted. It was discovered, however, that extraction with solutions of alkaline carbonates very closely obeyed the conditions laid down, and in actual practice it was found that a 1 per cent. solution of K_2CO_3 was the most convenient for general employment.

Comparisons were first made between soils from different portions of the Pusa Estate when it was found that although the total P_2O_5 did not vary appreciably and the available P_2O_5 estimated by the citric acid method was uniformly lower than 0·0005 per cent., the amount extracted by K_2CO_3 varied from about 0·0011 to 0·00321 per cent.

The next comparisons were made between a number of pairs of plots which had a known manurial history :—

Description of plots	Available P_2O_5 by	
	Citric acid	K_2CO_3
Punjab field. No manure	0·00029	0·00113
Do. Super	0·00029	0·00176
Punjab field. K_2SO_4	0·00022	0·00076
Do. K_2SO_4 and super	0·00019	0·00164
Pot culture house plots. No manure	0.00028	0·00321
Do. Super	0·00107	0·00466
Pot culture house plots. Am_2SO_4	0·00020	0·00299
Do. Am_2SO_4 and super	0·00020	0·00343
Pot culture house plots. K_2SO_4	0·00011	0·00347
Do. K_2SO_4 and super	0'00095	0·00447

In another case a plot which had received a dressing of super several years ago and none since gave 0·00221 per cent. P_2O_5 by K_2CO_3 extraction, whereas the corresponding no manure plot gave only 0·00132 per cent., and more recently, a supered plot gave 0·00227 per cent. as against 0·00139 and 0·00107 for unmanured plots.

Thus in practically all the cases examined, the method of extracting with K_2CO_3 has differentiated between manured and unmanured plots, whereas the citric acid method yields uneven values. This being the case, an examination was made of soils taken from a field showing very irregular growth in the crop, samples being taken from good portion for comparison with samples from bad parts :—

Description		Available P_2O_5 by	
		Citric acid	K_2CO_3
Good cropping soil	No. 1	0·00038	0·00126
	No. 2	0·00017	0·00183
	No. 3	0·00016	0·00173
	No. 4	0·00016	0·00183
Bad cropping soil	No. 1	0·00038	0·00132
	No. 2	0·00032	0·00139
	No. 3	0·00022	0·00139
	No. 4	0·00022	0·00101

Thus in three cases out of four the good soils yielded appreciably higher values than the bad soils with K_2CO_3 extraction, whereas with citric acid the reverse was the case.

These preliminary observations are extremely promising and will be further extended.

Effect of gypsum on the cropping of Pusa soils. In connection with the study of the relationship of superphosphate manures to calcareous soils it became of interest to determine the effect of gypsum contained in commercial supers on the cropping value of the soil. Pot culture experiments were laid down during two cropping seasons to test the effect of gypsum when applied alone or in combination with green-manures or monocalcic phosphate. The residual effect of gypsum on the crop following that to which it was applied was also tested.

As a result it was evident that gypsum exerted no beneficial effect, but on the other hand in the majority of cases it appeared to decidedly depress the yields. Arrangements were then made to test this on the field scale on one of the Punjab experimental plots of known cropping value relatively to the surrounding plots. All the plots were green-manured in a uniform manner and to the test plot a dressing of gypsum was applied at the rate of 84 lb. to the acre.

Taking the average of the yields for the past three years as basis, the experimental plot showed a *decrease* of 23 per cent., whereas the surrounding comparison plots showed an average *increase* of 16 per cent., thus clearly defining the depressing effect of gypsum. It is probable that this action of gypsum accounts in some measure for the uncertain reaction of super when applied to the Pusa fields.

The movement of nitrates in the soil and sub-soil. This investigation has been continued on the lines laid down in the previous year's report and has absorbed a large portion of the energies of this Section. The number of samples taken during the year have totalled 1,290 and great credit

is due to the First Assistant, Mr. Mukerji, and to the members of my staff for the energetic way in which the work has been carried on.

The report submitted last year carried the observations to the end of July when a heavy monsoon had washed the nitrate formed at the surface into the deeper sub-soil layers. The effect continued, and at the end of August in the more open type soil columns much of the nitrate had passed into the layers below the depth to which borings had been taken. In the case of those columns which contained heavy layers the nitrate was retained more effectively. It would therefore appear that from the point of view of conservation of nitrate the best types of soil are those which possess a fairly heavy layer of a depth from three to four feet.

In this connection an interesting set of observations was obtained from a field which had received a heavy application of green-manure. Decomposition was exceedingly rapid and within a fortnight from the burying of the manure the whole column might almost be said to be gorged with nitrate. By the end of August 1922 this nitrate had been carried down into the deeper layer, and subsequent borings showed that the cold weather crop obtained little benefit from it until late in the season. The amount of nitrogen lost was in the aggregate very heavy, and considering the subject from the point of view of nitrogen conservation the propriety of manuring with green-manure during the earlier stages of the monsoon is open to question.

From November 1922 onward the results obtained followed closely on the lines of those for 1921-22, and showed that as the crop matured the nitrate in the soil column was utilized to a depth depending on the character of the layers in the deep sub-soil. The evidence obtained was not in favour of any considerable upward movement of nitrate.

This investigation was extended to an area in Harpur Jhilli field planted with cane in February 1923 and heavily

manured later with cake. The most remarkable feature noticed hitherto has been the large formation of nitrate in the surface layers, but as the monsoon this year has only yielded about 8 inches of rain to date this nitrate has not been washed down into the sub-soil layers. An interesting speculation might be made on the probable fate of this nitrate during a heavy monsoon.

During the ensuing year an attempt will be made to extend the investigation to other crops and to land permanently under pasture.

VII. Programme of work for 1923-24.

Major subjects.

1. Continuation of the investigation into the amount and nature of drainage water from cropped and fallow land.

2. The influence of manuring on the composition of crop.

3. The mode of action of phosphatic manures in calcareous soils.

4. The determination of the available P_2O_5 in calcareous soils and its correlation with cropping value and manurial reaction.

5. The movement of nitrates in Pusa soils.

6. A study of the chemical and physical factors involved in combined applications of green-manures and superphosphate.

7. Variations in the quality of the milk from selected cows.

Minor subjects.

1. A comparison of the accuracy of various analytical methods.

2. Analytical work for other Sections.

VIII. Publications.

Harrison, W. H. . Report on Agricultural Chemistry, 1921-22, for the Board of Scientific Advice.

Sanyal, P. B. . A Method for the accurate Determination of Carbonic Acid present as Carbonate in Soil. *Pusa Agri. Res. Inst. Bull. 151.* (*In the press.*)

Mukerji, J. N. . Carbon-Dioxide in Soil Gases. *Agri. Jour. India.* (*In the press.*)

REPORT OF THE PHYSIOLOGICAL CHEMIST.

(A. Viswanatha Iyer, B.A.)

I. Charge and Staff.

Mr. F. J. Warth held charge of this Section from 1st July, 1922, to 6th April, 1923, when he proceeded on eight months' leave on average pay and I took over charge.

II. Development.

A considerable amount of development has taken place during the past year.

Reclamation, by extensive soil carting, has been effected on part of the area allotted to the Physiological Chemist.

A weighbridge has been purchased, set up, and housed within the standing area. A barn has been constructed. The possession of the barn has made it possible to lay in an ample food supply and to increase the live stock.

There are now 10 bullocks in the nutrition stalls and all are under experiment.

A trial shed was constructed for nitrogen metabolism experiments and its utility established. Using the experience gained from the temporary shed, a more permanent structure has now been erected for this work.

All this construction work, while it was in progress, very seriously interfered with the feeding experiments. These difficulties are now past and the experiments are proceeding, with the various facilities which have been provided, under greatly improved conditions.

III. Laboratory Work.

1. *Testing of methods.* Experiments under this head have been confined to an examination of the carbohydrates of paddy straw and their digestion. The work is in its initial stages and calls for no remarks.

2. *Pepsin soluble nitrogen.* The experiments of the previous year have been continued on all suitable material

from current digestion experiments. The work has now been placed on a much sounder basis by the discovery and application of a modified process which yields more concordant results.

The method consists in treating the sample with 500 c.c. of 0·1 per cent. N/10 HCl for 48 hours in an incubator at 37°C. After this the whole thing is filtered through a Buchner funnel aided by the pump, washed with water, and nitrogen determined in the residue. This gives the insoluble nitrogen.

In the matter of the determination of insoluble nitrogen in fodders like mustard cake, no difficulty was experienced and concordant results were obtained between duplicates, which left no doubt regarding the suitability of the method for samples like mustard cake.

But when the pepsin insoluble nitrogen in fresh fæces is determined difficulties seem to arise :—

(*i*) The action was not complete at the end of 48 hours.

(*ii*) The duplicates were not agreeing and the error was as much as 15 per cent.—generally between 1 and 3 per cent.

(*iii*) In some cases the filtration of the substance took as much as 24 hours, even when aided by the pump.

(*iv*) In some cases there appeared to be some fungoid growth.

To see the effect of time a series was started keeping the samples under the same conditions for different periods, the solution strength remaining the same as before, *viz.*, 500 c.c. of N/10 HCl with 0·5 grm. pepsin, and the results are given below :—

Table I.

	72 hrs.	120 hrs.	144 hrs.	168 hrs.	216 hrs.	264 hrs.
No. 1 . .	0·9025	0·8694	0·8318	0·8039	0·8078	0·7585
No. 2 . .	0·9340	0·8711	0·8291	0·8079	0·7872	0·7686

Simultaneous with the above another series was started using different strengths of acid but keeping the time factor constant. A modification in the washing of the residue was also undertaken. The washing in this case was done with N/10 HCl (using 250 c.c.) instead of with water as before, and the results are given below :—

TABLE II.

	N/10 HCl	N/5 HCl	
No. 1	0·8259 0·8298	0·7478 0·7520	Kept in the incubator for 96 hours.
No. 2	0·8286 0·8321	0·7509 0·7506	

On an examination of the figures in Table I it would be observed that there was fair agreement between duplicates for 120 hours, 144 hours, and 168 hours, but the differences for others were so abnormal as could not be put down for experimental error. When the washings were done with N/10 HCl the agreement between duplicates was remarkably good, the error remaining within 1 per cent. A perusal of the figures in Table II will illustrate the point.

As soon as the question of washing the residues was settled, another series in duplicate was started with different strengths of acid (N/10, N/5, N/2·5 and N.HCl) and the samples were filtered after 72 hours and 96 hours. The results are set out below :—

TABLE III.

Time	N/10 HCl	N/5 HCl	N/2·5 HCl	N. HCl
72 hrs.	0·6798	0·6191	0·5950	0·5982
96 hrs.	0·6704	0·6055	0·5796	0·5825

N.B.—Figures in Tables I, II and III represent percentages calculated on dry basis.

From a perusal of the figures in Table III it will be observed that there is practically no variation with the results obtained with N/2·5 HCl and N.HCl in the case of samples kept for 96 hours and the lowest limit has also been reached. From another series it was seen that there is no appreciable variation in the results obtained from those for 96 hours, keeping the strength of acid at normal, even if kept for longer periods than 96 hours. All these experiments have very nearly settled the technique for the pepsin treatment of fæces, *viz.*, the strength of acid to be normal and the period for which the samples are to be kept is 96 hours and washing the residues to get rid of the excess pepsin and dissolved nitrogen is to be done by N/10 HCl, at least 250 c.c. being used.

3. *Analysis of Indian foodstuffs.* Ninety-two samples of *jowar* (*Sorghum*), collected from different parts of the country, have been analysed during the past two years. Other data are being collected in connection with digestion experiments.

4. *Analysis of green fodders.* In the course of the digestion experiments on green fodders described below, it was found that on drying there occur losses of nitrogen which in some cases are too great to be ignored.

Table IV.

	Average from four days, 7-VI-23 to 10-VI-23	Average from four days, 11-VI-23 to 14-VI-23	Average from two days, 15-VI-23 and 16-VI-23
	Per cent.	Per cent.	Per cent.
Nitrogen in fresh lucerne .	2·874	2·829	2·623
Nitrogen in oven-dried lucerne.	2·845	2·313	2·446

Date	Sample	Fresh		Oven-dried	
		Per cent.	Per cent. average	Per cent.	Per cent. average
15th September 1922	Maize stalk	0·5938 0·5893	0·5891	0·4922 0·4957	0·4940
„ . . .	Maize leaf	2·0200 2·1030	2·0610	1·0310 1·0460	1·0380
„ . . .	Jowar stalk	0·6252	0·6252	0·6172 0·6099	0·6135
„ . . .	Jowar leaf	2·2100 2·2740	2·2420	1·9050 1·8940	1·8990

To make adequate allowance for such losses the preliminary feeding tests with green fodders involved very heavy laboratory work.

A new technique is now under trial by means of which it is expected to get over this difficulty.

5. *Analyses in connection with feeding trials.* The following analyses have been carried out during the last year :—

Concentrates and straw :—	
Complete analyses	31
Nitrogen only	41
Moisture only	134
Green fodders :—	
Complete analyses	9
Nitrogen only	154
Moisture only	138
Fæces :—	
Complete analyses	48
Nitrogen only	230
Moisture only	619
Urine :—	
Complete analyses	78
Nitrogen only	119
Total .	1,601

IV. Work in the Feeding Stalls.

1. *Digestion co-efficients.* During the past year, digestion co-efficients of nine typical concentrates have been determined. One of the samples was sent by the Bengal Department of Agriculture, one was a local sample and the remaining 7 came from military dairies.

2. *Digestion experiments with paddy straw.* The past year's work on paddy straw yielded some interesting results. The average digestion co-efficients found for fibre and nitrogen-free extracts were 72 and 44 respectively. The corresponding averages found in American experiments are 59 and 46. Given straw of average composition, these figures indicate that our bullocks have digested 10 per cent. more organic matter than was digested in the American experiments. These favourable results at Pusa may be due to a more highly developed digestion capacity of the breed of bullocks employed.

The figures for the apparent digestion of straw nitrogen demand special attention. It would appear that only in one set of tests did the animals derive any nitrogen from the straw. In the remaining tests the digestion was negative—more nitrogen being eliminated in the fæces than was supplied by the straw.

Table V.

Results of six experiments showing digestion of straw nitrogen.

Experiment	Per cent. nitrogen in straw	Quantity digested daily by	
		Kailas	Mahadev
		grm.	grm.
I	0·442	—3·30	
II	0·642	+4·10	+2·56
III	0·502	—1·37	—1·25
IV	0·492	—1·64	—0·76
V	0·402	—3·01	—1·78
VI	0·402	—2·82	—3·05

An inspection of this table makes it clear that the positive digestion in experiment II is associated with an unusually high nitrogen content of straw. In the succeeding experiments the nitrogen content of the straw diminished steadily, and with this diminishing nitrogen content of the straw there occurs a fairly regular increase of negative digestion. These results show that small differences in the nitrogen content of the straw may cause significant differences in nutritive effect. The nitrogen content of the straw, therefore, deserves attention.

A paper on these digestion experiments has been published in the " Agricultural Journal of India " (XVIII, 5, p. 456). Similar work with other straw has now been taken in hand.

3. *Maintenance experiments.* Some data on maintenance rations have been obtained and are appended below. Further determinations are in progress.

TABLE VI.

Maintenance rations in the Pusa experiments.

	Mahadev, body wt. 500 lb.	Kailas, body wt. 700 lb.	RATIO OF FOOD ASSIMILATED Mahadev : Kailas
	lb.	lb.	
Proteid	0·280	0·347	1 : 1·24
Carbohydrates	4·130	5·116	1 : 1·24
Fat	0·170	0·234	1 : 1·38
Nutritive ratio of digested food .	1 : 16·1	1 : 16·3	

The last column shows that the proportion of nutrients digested by the two animals agrees closely with the proportion in which the food was given, namely, 1 : 1·25.

The nutritive ratio of the digested food is seen to be a very wide one. It would appear that such ratio must be considered a normal one for bullocks in India.

The ration is, according to experiments now in progress, undoubtedly liberal as regards proteid.

4. *Nitrogen metabolism.* The designing and setting up of a new apparatus by Mr. Warth for this determination is the most important work which has been accomplished in the nutrition stalls. By its use the urine can be collected quantitatively for long periods (ten-day tests have been carried out) without inconveniencing or tiring the animals in any way. By means of this process nitrogen metabolism determination can be carried out with ease and accuracy.

The following experimental data illustrate the utility of the process.

A test with two bullocks, carried out continuously for five days, yielded the results shown in the accompanying table.

Table VII.

	Bullock A		Bullock B	
	Total urine in c.c.	Total nitrogen in grm.	Total urine in c.c.	Total nitrogen in grm.
1st 24 hours period . .	4,000	12·21	3,410	13·78
2nd „ „ . . .	4,220	12·10	3,980	14·19
3rd „ „ . . .	4,410	13·40	4,537	14·23
4th „ „ . . .	3,643	11·82	3,455	11·06
5th „ „ . . .	3,340	11·61	3,480	11·94

It will be seen that both animals gave a distinct maximum on the third day after which there was marked fall. These changes are due to the climatic factor, which, it is evident, may be readily studied with the aid of the apparatus.

A description of the process is published in the " Agricultural Journal of India " (XVIII, 3, p. 267).

Four nitrogen metabolism tests have been completed since the apparatus was set up.

5. *Experiments with green fodders.* A series of six digestibility determinations of green maize, *jowar*, and grass at different stages of development have been carried out.

An experiment to compare the feeding value of lucerne and berseem has also been completed.

In another set of experiments the minimum green fodder required to substitute for concentrates in a maintenance ration is being determined. This question is of considerable practical importance.

V. Programme of work for 1923-24.

Major subjects.

1. Determination of the digestion co-efficients of important Indian coarse fodders and concentrates.

Last year paddy straw yielded results which appear to be worth following up.

This year similar work will be carried out on a variety of straws.

2. The study of the nitrogen metabolism of Indian cattle.

To this enquiry the determination of maintenance rations has now been added.

The apparatus recently devised for nitrogen metabolism experiments offers certain advantages, is working well, and may be expected to yield useful results.

Experiments to study the influence of different types of food on the nitrogen balance have been commenced.

3. A study of the chemical methods involved in the above enquiries.

The routine analytical work has been to a great extent standardized.

Attention is now being directed to the estimation of carbohydrates in coarse fodders. Work on the nitrogen content of green fodders has also been undertaken.

Minor subjects.

Work on the minor subjects specified in last year's programme will be taken up as opportunity offers.

VI. Publications.

Warth, F. J. . . A Nitrogen Metabolism Stall for Bullocks. *Agri. Jour. India*, XVIII, 3, p. 267.

,, . . Digestion Experiments with Paddy Straw. *Agri. Jour. India*, XVIII, 5, p. 456.

REPORT OF THE IMPERIAL AGRICULTURAL BACTERIOLOGIST.

(C. M. Hutchinson, C.I.E., B.A.)

I. Administration.

I held charge of the Section throughout the year.

Mr. J. H. Walton, Assistant Bacteriologist, was on combined leave for one year from 17th February, 1923.

Mr. N. V. Joshi, First Assistant, acted as Assistant Bacteriologist in place of Mr. J. H. Walton.

II. Training.

Babu Indu Bhusan Chatterji, Assistant to the Agricultural Chemist, Bengal, was under training in this Section from 20th April, 1921. He finished his course and was relieved from this Section on 4th February, 1923.

Mr. Sanyasi Raju, a private student from Coimbatore, joined this Section, for a course of soil bacteriology, on 6th July, 1922. He was put to the Chemical Section to get a training in quantitative estimation of soil nitrogen and phosphate, as a preliminary to receiving instruction in this Section. He is now under training here from 7th October, 1922.

Mr. Ko Ko Gyi, Assistant to the Agricultural Chemist, Burma, is under training in this Section from 14th October, 1922.

Mr. K. R. Narayana Iyer, Agricultural Chemist, Travancore State, has joined this Section on 4th April, 1923, to undergo training in agricultural bacteriology.

III. Soil Biology.

Nitrogen fixation in soil by "non-symbiotic" organisms. The work on this subject previously reported

was continued and the following experiments were carried out :—

I. A large number of experiments was carried out to obtain further information as to the symbiotic relationship between algæ and nitrogen-fixing soil organisms. Large differences in fixation were found to occur as the result of the influence of light and darkness upon algal growth; thus in three months January to April the nitrogen fixed by a mixed culture of algæ and soil organisms was 1·19 mg. in the dark and 3·50 mg. in the light; a second series run from 2nd July to 1st August gave 2·55 mg. nitrogen in the dark and 9·6 mg. nitrogen in the light.

Fermented residues of a green manure crop (*Crotalaria juncea*) were used to replace mannite as a source of energy in a pure culture of azotobacter; 2 grm. of this material gave a fixation of 1·4 mg. nitrogen in 24 days, 4th July to 28th July, 1922. This would correspond in the field to a fixation of about 1·5 lb. nitrogen to the ton of green manure in three weeks' time. Other experiments were made using a variety of cellulose decomposition products.

II. The effect of various organic residues and compounds upon nitrogen fixation in soil.

Various green manures and crop residues were experimented with and large differences were noted in their suitability as sources of energy for nitrogen fixation by soil organisms; thus *bajra* (*Pennisetum typhoideum*) gave 33·96 mg. of added nitrogen, whilst cowpea gave 12·03 mg. and *asoka* (*Polyalthia longifolia*) leaves gave only 5·32 mg. over a period of 3 months. These amounts were greatly increased by the introduction of fermenting organisms in the form of a watery extract of cow manure. Previous fermentation of the organic residues considerably increased their apparent value as sources of energy for azotobacter and optimal periods of fermentation were found which varied with different materials. Thus maize which unfermented helped to fix 27 mg., when fermented for one month before adding it to the soil, gave a nitrogen increase of 47 mg.

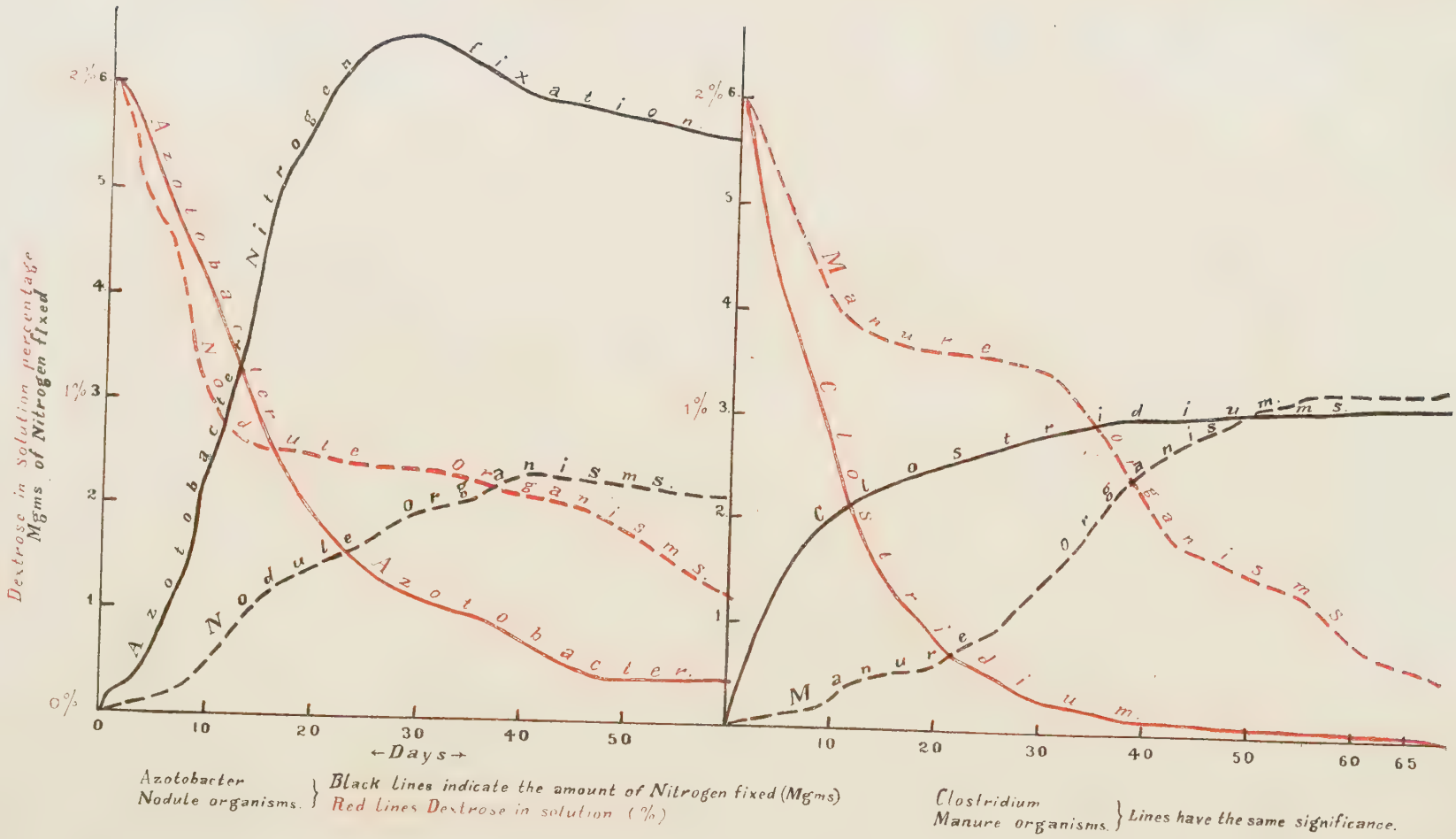
Dextrose in Solution percentage
Mgms. of Nitrogen fixed
2%
1%
0%
0
10
20
30
40
50
60
65
←Days→
Azotobacter Nodule organisms.
Nitrogen fixation.
Azotobacter Nodule organisms.
Nodule organisms.
Azotobacter.
Clostridium Manure organisms.
Manure organisms.
Clostridium.
Manure Clostridium organisms.
Clostridium organisms.
Manure Clostridium.
Azotobacter Nodule organisms. } Black lines indicate the amount of Nitrogen fixed (Mgms)
Red lines Dextrose in solution (%)
Clostridium Manure organisms. } Lines have the same significance.

PLATE I.

which was reduced to 34 mg. when fermentation had been continued for three months. Similarly fermented straw gave 19·3 mg. nitrogen as against 9·25 mg. nitrogen fixed in soil by unfermented straw over a 3 months' period.

III. Nitrogen fixation was found to occur in cowdung alone, and to be increased by some 15 per cent. by the addition of straw. Fixation also took place in a mixture of 15 grm. straw with 20 c.c. of a water extract of cowdung (1 grm. in 50 c.c.).

IV. Fixation of nitrogen in pure cultures of azotobacter was increased by small additions of nitrate (5 mg. per 100 c.c. of culture solution), larger amounts inhibited fixation completely and resulted in reduction of the added nitrate. Artificial aeration (by aspirated air) increased the amount of fixation from 8 mg. to 9 mg. per gramme of mannite and at the same time greatly increased the growth of azotobacter.

Experiments were made to determine the relative rates of utilization of dextrose by various nitrogen fixing organisms, azotobacter, clostridium, *B. radicicola* and a mixed culture from cow manure, in liquid culture. The results are shown in the accompanying graph (Plate I).

The effect of an indigenous rock phosphate on nitrogen fixation in pure culture by azotobacter was compared with that of basic slag; the former had a distinct depressive action, whereas slag has a decidedly beneficial effect.

V. Nitrogen fixation was found to be active in river silt and a vigorous growth of algæ occurred in this medium in diffused light. More than double the quantity of nitrogen was fixed in the light than when the silt was kept in darkness (17·3 mg. and 8·2 mg. per 100 grm. silt), thus affording further evidence of the symbiotic relationship existing between the algal growth and that of azotobacter. Addition of mannite added some 4 mg. nitrogen to the amount fixed without it.

Eight varieties of algæ, distinguished by morphological characters under microscopic examination, were tested in

pure cultures in symbiosis with azotobacter and gave varying results—some negative (3) and some positive increases—from 0·48 mg. to 2·4 mg. nitrogen above the controls. In a rich garden soil showing algal growth the amounts of nitrogen fixed in four months were: in darkness 54 mg.; in light 77 mg.; with nitrate (5 mg. per 100 grm. soil) in light, 91 mg. per 100 grm. soil. Artificial aeration in culture solutions containing algæ and azotobacter was found to depress nitrogen fixation to a considerable extent.

VI. Field experiments to determine the effect of various manurial and other treatments were commenced; the results will be reported later.

The facts above recorded, although forming no doubt but a fraction of the greater mass of information which will be necessary for any adequate understanding of this important subject, yet serve to indicate not only that progress is being made in the right direction, but that the possibilities connected with solution of the problem are fully as great as they appeared when that problem was first attacked. Briefly, we know by observation that large amounts of nitrogen can be added to Indian field soils by asymbiotic organisms, but nothing was known as to the causes responsible for the very wide variations in this amount in the same soils from year to year. The hopeful features of our results are that we have been able to obtain and establish similar variations under known and controlled conditions, these latter not involving the utilization of economically impossible sources of energy such as sugar or molasses, but taking advantage of our previous work on fermentation of organic residues and thus relying on indigenous raw material alone. The symbiotic relationships with algæ are naturally of extraordinary interest in this country where these organisms are present in every soil, and it can be only a matter of time and further research along the right lines before we are able to indicate in what manner the management of the soil may be modified so as

to increase the amount and rate of nitrogen fixation naturally taking place therein.

Nitrification. Further work on the activation of nitrification of cattle urine was carried out with a view to conservation of its nitrogen content. A method of doing this, suitable for use by the ordinary Indian cattle owner, was worked out, consisting essentially of the use of a suitably prepared aerating filter bed made of broken brick or rubble, the passage of the collected and diluted urine through this bed resulting in the formation of nitrates and recovery of the major portion of the original nitrogen content of the urine in this form.

The effect of composting with phosphates and sulphur upon the nitrification of various refractory sources of organic nitrogen such as *mahua* cake (*Bassia latifolia*) was further studied, in relation to the problem of solubilization of mineral phosphates by the same means. The general conclusion arrived at as a result of these experiments, in continuation of those of previous years, was that it is highly advantageous when dealing with the problem of the use of organic manures and residues, to make use of the method of fermentation under controlled conditions, already worked out at Pusa and recommended in the case of green manures.

The formation of nitrates and their vertical and horizontal distribution in soils under varying conditions of cropping and cultivation was further studied in field plots.

Green-manuring. The results of the green-manuring experiments on the Punjab Experimental Area of the farm were made the subject of a paper in the "Agricultural Journal of India." The continued residual effect of large applications of fermented green manure was a marked feature of the returns and the effectiveness of such applications in conjunction with the use of superphosphate was also most noticeable. The most remarkable result, however, was that obtained by putting in a fresh crop of green manure (*Crotalaria juncea*) over the whole area five

years after application of the original manurial and other differential treatment. The application of this green manure gave an immediate increase in the succeeding cold weather cereal crop over the whole of the plots, but the remarkable feature of the returns was the obvious persistence of the effect of the original applications of superphosphate on certain plots, although these were made five years before. The underlying causes are naturally obscure but the importance of the result from an economic point of view alone, has led to the initiation of experiments designed to throw light on this interesting problem, with special reference to the possibility of bacterial intervention playing a considerable part in the matter. A field scale experiment confirmed the conclusions drawn from small plots in the previous season that in using *sannai* (*Crotalaria juncea*) as a green manure it might be advantageous to combine with this operation the separation of the stems as a source of fibre, the tops and leaves alone being buried in the soil. The green manure effect of such separation on the following *rabi* crop was found in some cases to be better and in all cases to be at least equal to that of the whole plant.

Bacterial decomposition of organic residues. Further study of this subject with special reference to cellulose led to the isolation of a specific organism capable of dissolving cellulose under aerobic conditions but only in symbiosis with certain other soil bacteria of which several were found. None of these secondary organisms had any capacity for cellulose destruction either individually or in symbiosis with any other except the specific one first mentioned. The characters and relationships of these organisms will form the subject of a paper to be published in due course.

Solubilization of mineral phosphates. Further work was done on this subject in view of the importance of bringing into use the large, but at present scarcely touched, supplies of indigenous phosphates in this country.

By the use of cultures of sulphur-oxidizing bacteria, these being watered into composts containing rock phosphate and sulphur, very great advances were made in the percentage of phosphate rendered soluble. In the previous report it was shown that by composting phosphate, cake, and sulphur, some 4·3 per cent. of phosphate was solubilized in sixteen weeks. By the addition of bacterial cultures this amount was increased to 66·9 per cent. with one culture and to 88·9 per cent. with another, in a period of only ten weeks. These results were obtained with indigenous rock phosphates; the same cultures acting on pure tricalcic phosphate solubilized 65 per cent. and 95·9 per cent. respectively. An interesting observation was made as to the beneficial effect of additions of gypsum to the sulphur-phosphate compost. Such additions appeared to increase solubilization by improving the physical texture of the mass with regard to aeration, this latter condition being a vital factor in oxidation of sulphur by bacterial action. A paper on this subject was written for the "Agricultural Journal of India."

IV. Indigo.

Work on this subject was necessarily curtailed as a result of the death of the Assistant Bacteriologist Mr. Petty who had been specially recruited to deal with industrial research problems.

Experiments on the use of pure cultures of indican-hydrolyzing bacteria on a factory scale demonstrated the necessity of further work to ascertain the best methods of establishing such bacteria in the indigo vats in a concentration sufficient to secure the preponderance of their action over that of adventitious organisms unavoidably introduced with the water or the plant itself. In view of the closing down of the Indigo Chemist's Section and the abolition of the post of Assistant Bacteriologist in this Section, work on this subject must necessarily be

relegated to a subordinate position. Some interesting observations were made on the losses occurring between steeping and beating; it was found that an interval of at least one hour may be allowed without appreciable deterioration or loss. A series of experiments on the neutralization of the fermented liquor with caustic soda before beating gave results which led to definite conclusions of practical value. In cases where fermentation and settling are normal no advantage is to be obtained by the use of soda; when, however, fermentation is poor, settling bad, and produce low, neutralization with caustic soda may be recommended as likely to result in improved settling and increased yield of indigo. The results of these experiments are detailed in an Indigo Publication now in the press.

A considerable amount of work was done on the subject of sterilization of indigo paste. Numerous bacteria were isolated from paste in a fermenting condition, some samples of which had been imperfectly sterilized in England with paranitranilin and others by heat. The thermal death point of these was determined and recommendations as to appropriate methods of sterilization by heat were made.

V. Bacterial infection of Sugar Mills.

Investigations were made of the character and specific action of various organisms found as contaminations in the cane juice of sugar mills in Bihar. A constant small percentage loss of sugar occurs in the mill part of which is probably due to inversion during the short time of passage from the rollers to the evaporating plant. Although a large number of organisms were found, only a few of these possessed any considerable inverting power, and further work will be required to determine the practical significance of their presence in the cane juice in the mill. It appears probable, however, that some degree of antiseptic precaution in the mill would be attended with advantages.

VI. E.C.

Further work on this antiseptic has now led to the standardization of a type of electrolytic apparatus specially designed for its preparation and made by Messrs. Mather and Platt of Manchester. This apparatus is specially designed for use in hospitals and can be run on an ordinary lighting circuit without any expert knowledge. As this preparation has a carbolic co-efficient of 3·9 and is made from entirely indigenous materials at a very low cost its use should allow of great savings in outlay on antiseptics whether for hospital or other purposes, and especially for sterilization of water as a preventive measure against cholera.

I read a paper on this subject before the Medical Section of the Indian Science Congress at Lucknow. Arrangements were completed to supply the Government of Bihar and Orissa with sufficient quantities of E.C. to meet the requirements of five of the principal hospitals in that province until such time as these institutions should be in a position to produce their own supplies. The appointment of a special officer to take charge of this production for the province has been sanctioned by the Local Government.

VII. Programme of work for 1923-24.

Major.

Soil biology—

This will include continuation of the work above reported on nitrogen fixation, nitrification, solubilization of indigenous phosphates, and the role of soil bacteria in modifying the supply of available phosphates to crops.

Training of students.

Industrial biology—

Owing to the abolition of the post of Assistant Bacteriologist the programme of work on the

subjects coming under this head will necessarily be very much restricted in scope and will not include the work it was hoped to carry out on the important subject of fermentation of foodstuffs.

Work will be done on dairy antisepsis.

Minor.

Bacterial diseases of plants.
Biological analyses of soils.
Pure cultures of yeasts and other fermentation organisms.
Minor industrial researches.

VIII. Publications.

Hutchinson, C. M. . Source of Error in Pot Culture Experiments. *Agri. Jour. of India,* Vol. XVII, Pt. V, Sept. 1922.

,, A comparison of E.C., Bleach and Chlorogen. *Ind. Med. Gazette,* Vol. LVII, October 1922.

,, The value of Fermented Green Manures as tested at Pusa by the prevalued Plot Method. *Agri. Jour. of India,* Vol. XVIII, Pt. III, May 1923.

,, Report on Agricultural Bacteriology, 1921-22, for the Board of Scientific Advice.

Joshi, N. V. . . Comparative manurial value of the whole Plants and the different parts of Green Manures. *Pusa Agri. Res. Inst. Bull. 141.*

REPORT OF THE IMPERIAL MYCOLOGIST.

(W. McRae, M.A., B.Sc., F.L.S.)

I. Charge and Establishment.

Throughout the year I was in charge of the Section and Dr. Shaw was Second Imperial Mycologist. Mr. J. F. Dastur left on the 12th February to take up an acting appointment of Mycologist to the Government of the Central Provinces.

II. Training.

Mr. T. N. Sen, B.A., a private student, completed his course of training in November. Mr. Sankara Menon, B.A., B.Ag., a member of the Agricultural Service of Cochin State, had a six months' post-graduate course. Sirdar Niranjan Singh, Demonstrator in Botany, Khalsa College, Lahore, worked in the laboratory from July to September, and Mr. H. N. Das, Lecturer in Botany, Government College, Lahore, for two weeks in September.

III. Diseases of Plants.

(1) **Cereals.** The work on *Piricularia* found on various cereals and grasses was continued but no marked results were recorded. The sclerotial fungus found on rice plants last year has been shown by experiment to produce on the leaf-sheaths light yellow brown spots sharply demarcated by a dark reddish brown line that gradually spreads over the plant so that death ensues. By eight days after the infective material had been sown the plants were dying in considerable numbers and nearly all were dead within three weeks. The fungus is not yet definitely determined. Infection experiments with it on sugarcane were not successful and its identity with the fungus causing the disease known as Djamoer Oepas in Java and also found in India is still

not established though the two fungi in their sclerotial stage appear morphologically to be the same. Infection experiments with the species of *Cephalosporium* isolated from barren rice plants from Assam gave negative results on rice plants grown in Pusa soil. They will be repeated on soil of a different type.

From the field experiments at Pusa to control smut caused by *Tolyposporium Penicillariæ* on *bajra* (*Pennisetum typhoideum*) no definite conclusions could be drawn regarding the effects of seed treatment on the prevention of the smut because the incidence of the disease was slight. Nor at Baroda were the results more definitely conclusive, but the Director of Agriculture reports that the smut on treated plots was decidedly less than on untreated plots on the farm. As this smut is unknown in Mirpurkhas and Lyallpur, seeds obtained from these places by the courtesy of the Deputy Director of Agriculture, Karachi, and the Professor of Agriculture, Lyallpur, were sown at Pusa and Baroda. At Baroda these varieties were as much smutted as the local varieties. At Pusa they had no smut but then there was remarkably little smut in *bajra* in Pusa this season. Seed treatment against downy mildew of maize also gave no results because of the very slight incidence of disease. The plants from the treated seed seemed larger and greener at first but by flowering time there was no visible difference between the two sets of plots. Mildew was observed in July but never spread. It is remarkable that both smut and mildew did so little damage in Pusa as this monsoon was a heavy one with hardly any breaks so that the humidity was continuously high yet the temperatures were uniformly lower and that probably accounts for the mildness of these diseases.

Foot rot of wheat in Dharwar and the Central Provinces causes considerable loss in all stages of growth. Several fungi were isolated from diseased plants and their pathogenesis was investigated. A species of *Helminthosporium* obtained from both localities was shown to be able

to kill wheat seedlings. This fungus is possibly the cause of the disease but its connection, if any, with the species of *Acrothecium* and *Alternaria* often found associated with it and sometimes *Rhizoctonia* is under investigation. Foot rot is said generally to be found in those fields which have been sown early, so it is just possible that in areas where the disease causes much loss if the sowing be delayed till the cold weather has really set in there would be very little trouble.

The study of the genus *Helminthosporium* on cereals was continued with special reference to the relationship between those on grasses and crop plants. The species on wheat considered to be a strain of *H. sativum* showed great variation in culture. Of the variants isolated some reverted after a few generations to the characteristics of the parent culture while others remained constant. When these were inoculated on to wheat plants the fungus isolated from diseased spots however had the character of the original strain.

(2) **Jute.** The experiments to determine the influence of applications of sodium sulphate as manure on the growth of jute and the incidence of disease were continued in two plots. That which had received applications of sodium sulphate contained 1,399 plants weighing 553 lb. and disease was entirely absent. The other plot which had not received sodium sulphate contained 1,342 plants of which 744 were diseased. The weight of this crop was only 220 lb. A more extensive series of field experiments has been laid down to test the accuracy and applicability of the result indicated by the experiments which have been in progress. The influence of the composition of the soil upon the incidence of disease in jute is also being studied in the laboratory by a series of cultures designed to test the effect of certain constituents of the soil on the growth of the fungus in culture. Up to the present work has been confined to devising methods by which the amount of growth in a normal culture solution under constant conditions may

be measured. Considerable difficulty has been experienced in keeping all the factors constant. In particular the introduction of equal amounts of the inoculum is a factor of considerable importance in the amount of growth produced.

(3) **Cucurbitaceæ.** Strains of *Pythium* were found to be prevalent on certain members of the Cucurbitaceæ that are grown as vegetables and that were rotting in considerable numbers. Strains were isolated from *Luffa acutangula*, *Luffa ægyptiaca*, *Trichosanthes anguina* and *Lagenaria vulgaris* and their morphology studied.

(4) **Rahar.** The wilt caused by *Fusarium udum* on pigeon pea (*Cajanus indicus*) was most severe this season. In the permanent manurial series of experiments at Pusa the number of wilted plants has been recorded in three seasons in each of the two series in alternate years. The numbers recorded in plots that are comparable are as follows :—

Plot No.	A Series			B Series		
	1918-19	1920-21	1922-23	1917-18	1919-20	1921-22
I	381	172	725	129	47	37
XIII	511	237	604	233	252	141
XIV	189	93	464	386	415	215
VI	117	93	394	346	360	248
VII	154	99	543	588	393	365
Average	230	139	546	338	293	201
II	445	302	683	126	76	71
III	307	216	587	319	250	275
IV	478	441	1,210	703	760	886
Average	410	320	816	383	362	411

Plot No.	A Series			B Series		
	1918-19	1920-21	1922-23	1917-18	1919-20	1921-22
VIII	698	995	1,849	1,903	1,452	898
IX	1,035	1,128	2,236	2,354	1,222	718
X	1,017	1,014	2,734	1,814	989	719
Average	917	1,046	2,273	2,024	1,221	778
XV	82	32	85	111	189	66
XVI	99	124	689	511	642	387

Plot I received no manure.

Plot XIII received no manure.

Plot XIV received no manure, a shallow rooted legume grown in the rotation.

Plot VI received sulphate of ammonia to supply 20 lb. nitrogen per acre.

Plot VII received sulphate of potash to supply potash as in plot III.

Plot II received farmyard manure to supply 10 lb. nitrogen per acre.

Plot III received farmyard manure to supply 20 lb. nitrogen per acre.

Plot IV received farmyard manure to supply 30 lb. nitrogen per acre.

Plot VIII received superphosphate to supply P_2O_5 as in plot III.

Plot IX received sulphate of potash to supply potash as in plot III and superphosphate to supply P_2O_5 as in plot III.

Plot X { received sulphate of ammonia to supply nitrogen as in plot III. / sulphate of potash to supply potash as in plot III and superphosphate to supply P_2O_5 as in plot III.

Plot XV received green manure.

Plot XVI received green manure and superphosphate to supply P_2O_5 as in plot III.

The average of the super plots is—

4	7·5	4 in A Series	} times the average of the
6	4	4 in B Series	} no phosphate plots.

The average of the cattle manure plots is—

2	$2\frac{1}{2}$	2 in A Series	} times the average of the
1	1	2 in B Series	} no phosphate plots.

The average of the green manure plot is—

0·36	0·23	0·15	} of the average of the
0·32	0·64	0·23	} no phosphate plots.

It appears that those plots that receive superphosphate carry an increased number of wilted plants that is significant, and that the green manure plot has so small a number as to be significant. The cattle manure plots receive small but increasing doses from plot to plot and the number of wilted plants is highest in the plot that gets the largest dose, yet the numbers are not so different as to appear to have definite significance beyond indicating a possible tendency that could be tested by plots that received larger quantities of cattle manure. The fact that in the green manure plot to which superphosphate had been added the numbers of wilted plants are very slightly higher than in the plots that get no phosphate seems to indicate that the superphosphate neutralizes the depressing effect of the green manure on the incidence of the disease. Experiments are in progress to elucidate the effect of phosphate on the plant and on the fungus and the effect of mineral phosphate as compared with phosphate in association with organic matter in cattle and green manures. This subject is of importance inasmuch as green manure and superphosphate has a great effect in increasing the yield of other crops on the alluvium and *rahar* is one of the crops in the usual rotation.

IV. Systematic Work.

Six hundred and eighty-eight specimens from within and outside India were added to the herbarium and 162 specimens were sent to mycologists in various parts of the world. One hundred and thirty-eight specimens of fungi on various plants were prepared and sent to the Imperial Bureau of Mycology, London, for final identification. A supplementary list of specimens added to the herbarium from May 1921 to December 1922 was issued in typewritten form.

V. Programme of work for 1923-24.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated. The following crops and diseases will receive special attention :—

(*a*) Diseases of cereals.
(*b*) Diseases of sugarcane.
(*c*) Diseases of jute.
(*d*) Diseases of *rahar*.
(*e*) Diseases of gram.

(2) *Systematic work.* This will be carried out in conjunction with the Imperial Bureau of Mycology in London. Steps will be taken to print supplements to the list of specimens in the Pusa herbarium for the assistance of the provincial sections of mycology.

(3) *Training.* Students and assistants will receive training on the lines indicated in the prospectus.

(4) *Routine work.* Advice and assistance as required will be given to other departments and the general public.

VI. Publications.

McRae, W. . . Report on Mycology, 1921-22, for the Board of Scientific Advice.

Mitra, M. . . . *Helminthosporium* on Cereals and Sugarcane, Pt. I (*Helminthosporium* Diseases of Maize and *Jowar*). *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 10.

McRae, W. . . I.—History of the Operations against Budrot of Palms in Southern India. II.—Inoculation Experiments with *Phytophthora palmivora* Butl. on *Borassus flabellifer* Linn. and *Cocos nucifera* Linn. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XII, No. 2 (*In the press*).

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.)

I. Administration.

The Imperial Entomologist held charge of the Section throughout the year ended 30th June 1923, the Section now including both the old Entomological and Pathological Entomological Sections whose budgets were combined from 1st April 1923.

Mr. G. R. Dutt, Personal Assistant, in addition to his own duties, officiated as Second Entomologist from 3rd to 17th May 1923, during the absence of Mr. P. V. Isaac on leave. Mr. S. K. Sen, Assistant, acted as First Assistant for one month and 23 days, from 18th April 1923, during the absence on leave of Rai Bahadur C. S. Misra, whose title was granted to him in the New Year Honours. Mr. P. G. Patel, Assistant, who was on deputation in the Punjab, working under the Camel Specialist, Sohawa, died on 13th September 1922, and Mr. Ahmed Mujtaba, Fieldman, was promoted to Assistant in the vacancy thus caused.

II. Training.

Mr. Hira Lal, a student from the Government College, Lahore, was given facilities for work in the laboratory during his vacation from July to September. The Veterinary students from Muktesar, who attended the Entomological Meeting in February, were given a short course of instruction on the Insect Pests of Domesticated Animals in India. Specimens of Biting Flies were also supplied to the Cavalry School, Saugor, for instructional purposes. Mr. F. D. Peries, a student deputed by the Ceylon Government, was admitted to the general course in Entomology from 1st June 1923. Two students from Bhopal were put through the short course in Lac-work during June 1923.

III. Insect Pests.

Work on Borers in sugarcane and other gramineous plants was continued. Countings of dead-hearts caused by different species of larvæ were made and search for alternative food plants of the borers in the wild varieties of sugarcane and grasses was continued. No further novelties, however, were met with. This seems to indicate that our past investigation of the species occurring around Pusa has been fairly thorough. Much more work, however, remains to be done in checking details of life-histories and investigation of control, both natural and artificial.

As in previous years, observations and records were continued of the pests occurring on farm and vegetable crops at Pusa. Notes were also continued on pests of garden flowers. The following pests were especially noted during the year :—

Diacrisia obliqua on jute; this was very troublesome during the Rains and was kept in check by hand-picking and removal of alternative food plants (mostly weeds). It also occurred on swedes, *val* (*Dolichos lablab*), radish, sunflower, etc.

Prodenia litura on castor, jute, lucerne and violets.

Termites on sugarcane and in buildings.

Monophlebus contrahens on peach, plum and mango. This Coccid, which used to be abundant, has been greatly reduced in numbers during the last four years or so, but is now gradually increasing again.

Scirpophaga xanthogastrella (*auriflua*) in sugarcane.

Red Spider (*Tetranychus bioculatus*) on jute, castor, and *Hibiscus abelmoschus*.

Pelamia undata on velvet bean and *urid* (*Phaseolus radiatus*).

Giaura sceptica on soy-bean and velvet bean.

The study of Fruit Pests was continued, special attention being given to the pests of mango, guava, peach, plum, litchi, grape, and *Citrus*. The life-history of *Euphalerus citri*, together with its parasites, was worked out. Indigenous varieties of grape-vine were found heavily infested with *Phenacoccus* sp. and this is still under observation. Investigation of Fruit Pests, especially *Aspidiotus perniciosus*, in Kashmir was taken up towards the close of the year and is still in progress.

The Sectional cotton plants, sown in 1921, were in the ground throughout 1922 and were uprooted in June 1923. Observation and record of the insects found on the plants were kept, special attention being paid to *Oxycarenus lætus*, whose life-history was worked out and repeated twice during the year with special reference to its connection with boll-fall. In some varieties of cotton and at particular seasons the boll-shedding is especially pronounced and as such has a considerable bearing on the ultimate outturn of the crop. It has been suggested in Madras that the abnormal shedding of bolls is connected with the presence of Capsid (Mirid) bugs (*Ragmus* spp.) on the plants. In this connection intensive observation was made of a few selected cotton plants of different varieties to note the presence of any sucking insects which could directly or indirectly affect the boll-fall. So far, we have not been able to connect the boll-fall with the abnormal presence of any Capsid bug on the plants, but the presence of large numbers of nymphs of *Oxycarenus lætus* and *Dysdercus cingulatus* seems to increase the boll-fall considerably. But what is the actual effect of the presence of these bugs on the plant and what is their share in boll-shedding, or what proportion of this is due to purely physiological causes, are points which require further investigation.

The following are some of the more interesting insects sent in by correspondents during the year :—

(1) *Ætherastis circulata*, Meyr., reared from caterpillars on Para rubber trees in South India.

(2) *Mimela passerinii*, Hope, and *Anomala flavipes*, Arrow, the beetles eating leaves of cherry near Simla.

(3) *Hieroglyphus banian*, Fb., damaging sugarcane in Champaran District.

(4) *Hellula undalis*, Fb., damaging cauliflower seedlings at Peshawar.

(5) Jassid bugs on cotton at Kamrup, Assam.

(6) Fruit Flies from the North-West Frontier Province.

(7) *Rabila frontalis*, Walk., (Noctuidæ) bred from cotton-bolls in Madras.

(8) *Hoplocerambyx spinicornis* and two undescribed longicorn bettles of the genus *Praonetha* found around Para rubber trees in Mergui, Burma.

(9) *Plocæderus obesus* in *Odina wodier* wood at Gazipur.

(10) Galls on leaf of unidentified jungle plant in the Lushai Hills.

(11) *Agrotis* larvæ damaging vegetable plots at Bettiah.

(12) Rose-stems affected with *Aspidiotus orientalis* and *Chrysomphalus aurantii* in Champaran.

(13) Ground-nut and coco-nut cake infested with *Lasioderma testaceum* and a few *Tribolium* from Ernakulam.

(14) *Bruchus affinis* in dried peas and *B. analis* in dried gram at Kasauli.

(15) *Sipalus hypocrita*, in all stages, boring dead wood of Para rubber trees in Mergui.

(16) *Indarbela theivora* on tea-bushes in Pirmad.

(17) *Cirphis unipuncta* caterpillars damaging wheat in Baluchistan.

Besides the above, many other consignments of insects were received from correspondents and necessary identifications and advice were given as far as possible. In addi-

tion to the foregoing, the usual rearing work was carried out in the Insectary. Due to pressure of other work, many of the insects so reared remain unnamed, but amongst identified species may be noted *Apomecyna histrio* larvæ in old dried stem of *Dregea volubilis*, *Acherontia lachesis* larvæ on *Tecoma grandiflora* and larvæ of *A. styx* on *Vitex negundo* leaves, *Calandra stigmaticollis* larvæ boring semi-decomposed leaf-base of *Borassus flabellifer*, *Norraca longipennis* (Ceruridæ) larvæ on bamboo leaves, *Argina cribraria* larvæ on *Tephrosia purpurea* leaves, and *Dasyses rugosellus* breeding in the refuse in the crown of a date-palm.

Pathological Entomology. Work under this heading (apart from the systematic side, dealt with under Insect Survey) has been continued mainly with reference to Veterinary Entomology. With regard to this there seems to be need of a publication dealing with the insect pests of domestic animals in India, for the use of Veterinary Officers and Colleges, and considerable progress has been made in the preparation of a book on these lines by the Imperial Entomologist in collaboration with his Assistant, Mr. S. K. Sen. Of this proposed text-book a considerable proportion of the text has been written and a large number of illustrations prepared, and it is hoped that it will be completed during the ensuing year. This has necessitated the revision of a large amount of previous work, both published and unpublished, the collection of a large amount of new material and the investigation of numerous life-histories of cattle-flies, etc., all of which represents work which would normally be included in the Annual Report; but, as it is proposed to publish these results separately, it hardly seems necessary to discuss them here in detail.

Mr. P. V. Isaac, Second Entomologist (Dipterist), has been employed almost exclusively on Tabanidæ, the Indian species of which have hitherto received much less attention than is warranted by their importance as pests of animals. Very little, in particular, is on record regarding their life-

histories and habits, and these have been under investigation as regards the species commonly found at Pusa. The life-history of *Tabanus albimedius*, Wlk., has been completely worked out. One most interesting observation is that the larva of this Tabanid has seven instars; hitherto, no definite observation of the number of moults in Tabanid larvæ appears to have been published except for an obviously incorrect statement by Mitzmain that the larva of *T. striatus*, Fb., in the Philippines moults three times. The head and mouth-parts of *T. albimedius* larva have been studied and these larvæ, as well as other Tabanid larvæ examined, although mandibulate, seem to suck their prey. The life-histories of other Tabanidæ have also been partially studied, the species receiving attention being *T. striatus*, Fb., *T. bicallosus*, Ric., *T. nemocallosus*, Ric., *T. virgo*, Wied., *T. crassus*, Wlk., *Gastroxides ater*, Saund., and *Hæmatopota javana*, Wied. Many facts regarding the habits of adult Tabanids have also been recorded.

The local mosquitos found at Pusa have also been under observation. The species found breeding in bamboo traps were as usual *Aedes* (*Stegomyia*) *albopictus*, *A.* (*S.*) *thomsoni*, *A.* (*S.*) *W-alba*, *A.* (*Finlaya*) *lophoventralis*, *Armigeres obturbans*, *Culex fatigans* and *C. brevipalpis*. The mosquitos breeding freely in the river were *Anopheles fuliginosus*, *A. culicifacies* and *Culex bitæniorhynchus*, which begin breeding about the end of December, when the algæ serving as their larval food begin to appear, and continue breeding until the commencement of the rainy season. *Uranotænia campestris*, Leic., a rather rare mosquito at Pusa, was found breeding in October in a tank near the cemetery.

A Hippoboscid fly, new to us and perhaps a species of *Ornithomyia*, was collected in some numbers, both adults and puparia, in nests of the Indian Sand-Martin (*Riparia brevicaudata*) made in holes in the river-bank.

Larvæ of *Gastroxides ater*, Saund., (Tabanidæ) were collected from tree-holes between November and January,

the first adult emerging on 21st June and other flies appearing after a few days.

Further search has been made for the early stages of *Bengalia* (*Ochromyia*) but hitherto without success. The larvæ must be both comparatively large and of common occurrence and almost certainly occur in the ground "within six feet of one's nose," possibly as parasites of earthworms or sucking the blood of toads hibernating in the soil, and further endeavours will be made to solve the problem of their biology.

Specimens of *Gonocephalum hoffmannseggi*, Stev., were received from the Chemical Examiner, United Provinces, with inquiry regarding its poisonous properties. In this connection also we received from the Assistant Surgeon, Provincial Laboratory, Assam, some specimens of the Meloid Beetle, *Epicauta hirticornis*, with the report that a small boy had died twelve hours after eating four of these beetles roasted.

We are indebted to Dr. D. F. Michael, of the Pusa Hospital, for further material and notes of cases of human myiasis caused by the larvæ of the Muscid Fly, *Chrysomyia bezziana*, Vill. As noted in last year's Report, this fly appears to be an important cause of human myiasis in North Bihar. It is, of course, also a common cause of myiasis in domestic animals. Although the larvæ are found not uncommonly, the adult fly is rarely seen on the wing under natural conditions; one fly was taken flying around a pony and apparently attacking it but examination failed to reveal either eggs or larvæ.

In April the Imperial Entomologist commenced at Muktesar, in collaboration with the Imperial Bacteriologist, a series of experiments on the cyclical transmission of the rinderpest organism, and these have been continued by Mr. S. K. Sen on the departure of the Imperial Entomologist to Kashmir to investigate Fruit Pests. As these experiments were still in progress at the end of the year and have been done in connection with unpublished work

by the Imperial Bacteriologist on the rinderpest organism, any account of them must be deferred for the present.

In February the Imperial Entomologist attended the Second Veterinary Conference at which were discussed several subjects concerned with insect pests of domestic animals and insect-borne diseases. It was recommended by the Conference that, on account of the great importance of insects in the transmission of animal diseases and as causes of direct injury to live-stock in India, the staff of the Imperial Entomologist should be strengthened to the degree requisite for rendering assistance to investigators engaged in the study of animal diseases.

IV. Bees and Lac.

Bees. Four colonies of *Apis indica* were hived. Advice and suggestions regarding Apiculture were given to numerous inquirers in different parts of India. The subject of Apiculture in India requires the services of a whole-time expert in this line if work is to be taken up seriously. That there is a large demand in India for honey is certain and it is no less certain that the demand could be met if bee-keeping on modern lines were taken up.

Lac. The emergence of larvæ took place at Pusa on 16th October 1922 and 26th June 1923. The October crop was heavily parasitized by a Chalcidid, which was studied. Ber brood-lac was supplied in small quantity (all that could be spared) to the Madras Forest College and the Indian Institute of Science, Bangalore.

Rai Bahadur C. S. Misra visited the Central Provinces in order to study the damage done to the lac crop by the Noctuid moth, *Eublemma amabilis*. An examination of the crop in the Raipur and Hoshangabad Divisions showed that the damage done by this moth was very severe, in some places experimental cultivations being completely wiped out at a time when the crop had been growing vigorously on the trees. A paper on *Eublemma amabilis* was com-

municated to the Fifth Entomological Meeting and appears in the Report of the Meeting.

Bulletin No. 28, on Lac-culture in the Plains of India, having been out of print for some time, was entirely re-written and the revised edition published as Bulletin 142.

Three students were trained in Lac-culture during the summer session in June, two of these being deputed from Bhopal for the lac course and the third being a student from Ceylon under general training in Agricultural Entomology.

V. Illustrations.

The artist staff was largely employed during the year on the preparation of illustrations for the proposed book on Veterinary Entomology and on routine work in connection with the investigation of life-histories, etc.

VI. Insect Survey.

Steady progress has been made in additions to, and arrangement and identification of, the collection of insect specimens, which, as it expands, becomes constantly more valuable for present and future work, and which is increasingly taken advantage of by the Provincial Staffs and other workers on Indian Entomology for the identification of their material.

The collections are in good order but an unduly high proportion is still contained in store-boxes which have proved very unsatisfactory for the proper preservation of insect specimens in a climate such as that of Pusa. A small number of cabinets is being obtained but at the present rate of progress it will be many years before all our valuable, and in many cases irreplaceable, material is placed in secure storage.

A number of collections have been sent out during the year to various specialists for examination and identification and our thanks are due to all who have assisted us in this way.

Several lots of Odonata have been sent to Major F. C. Fraser, who has returned them named and has described the novelties either in our *Memoirs* or in the *Journal of Bombay Natural History Society.*

The Dermaptera are still with Mr. Morgan Hebard, to whom a further supplementary collection was forwarded during the year, and who has recently published a report on our collection, including the descriptions of ten new species, in No. 11 of Vol. VII of our *Memoirs.*

Of the Orthoptera, several lots of Acrididæ have been sent to Mr. B. P. Uvarov, who has returned part after naming and reported on the Rice grasshoppers of the genus *Hieroglyphus* in a paper published in the *Bulletin of Entomological Research*, Vol. XIII, pp. 225-241. More material will be sent to Mr. Uvarov, who is now engaged in a revision of the Indian short-horned grasshoppers, in which connection he contributed a paper to the Fifth Entomological Meeting. The collection of Acrydidæ is still with Mr. Hebard, to whom a few recent accessions have also been forwarded.

Our collection of Blattoida and Mantoida are also with Mr. Hebard, to whom recent accessions were sent during the year.

The Anoplura have received special attention during the year in connection with the study of the lice found on domestic animals. The previous small collection has been brought together and gone over and a large amount of new material has been got together and incorporated. We are indebted to Mr. C. M. Inglis for several lots of Mallophaga from identified birds and to the Government Entomologist, Madras, for Siphunculata from domestic animals.

Amongst the Homoptera, special efforts have been made to procure further material in Derbidæ, Jassidæ, Aleyrodidæ and Coccidæ. Specimens of the castor Aleyrodid were sent to Dr. Quaintance for examination.

Of the Hemiptera, our collection of Miridæ (Capsidæ), which was sent to Mr. E. Ballard for study, has been

returned by him partly named and he has also forwarded, for publication in our Memoirs, descriptions of novelties in this group.

In Coleoptera, the Hydrophilidæ have been returned named by Monsieur A. d'Orchymont, who has described the collection in No. 1, Vol. VIII, of our *Memoirs*. A further collection of Curculinidæ was sent to Dr. G. A. K. Marshall, who has returned it in part. The Erotylidæ, Endomychidæ and some Rutelidæ have been sent to Mr. Arrow. The Chrysomelinæ, Halticinæ and Galerucinæ are being sent to Mr. Maulik in connection with his preparation of a *Fauna* volume on these groups. Practically all our Meloidæ are with Mr. K. G. Blair, also in view of the preparation of a *Fauna* volume. A further lot of Carabidæ has been received back from Mr. H. E. Andrewes, to whom our material in this group is sent as it accumulates. Dr. M. Cameron has also returned some more Staphylinidæ.

Of the Neuroptera, a further small supplementary collection has been forwarded to Mr. Esben-Peterson, who is at present engaged in working out our material in most of the Families of this Order. Our small collection of Coniopterygidæ has been sent to Mr. Withycombe, and living material of *Croce filipennis* has also been sent to him and to Dr. Tillyard, but unfortunately did not survive the journey.

In Hymenoptera, some of our Apidæ are still with Professor Cockerell, the Encyrtidæ have been sent to Senor Garcia Mercet, who has undertaken their examination, and specimens of a species of *Phanurus*, parasitic on egg-masses of *Tabanus albimedius*, have been sent to Mr. Waterston for identification. Mr. G. R. Dutt has published an annotated list of the Ichneumonidæ in our collection (*Memoirs* Vol. VIII, No. 2).

In Lepidoptera, all unnamed or doubtful Lycænidæ and Hesperiadæ have been sent to Mr. Riley for examination during preparation of *Fauna* volumes on these groups or

Butterflies. A large number of Geometridæ have been identified and returned by Mr. L. B. Prout, and Miss Prout has kindly undertaken the examination of our undetermined Noctuidæ, which will be forwarded in due course. A named duplicate collection comprising 200 species of Indian Microlepidoptera was sent to the United States National Museum for study by Mr. A. Busck. Many descriptions of novelties from our collection have been published in "Exotic Microlepidoptera" by Mr. E. Meyrick, to whom further recent accessions remain to be forwarded.

In Diptera, several lots of Muscidæ have been sent to Major W. S. Patton, who has returned them in part. The *Muscidæ testaceæ* and Sarcophagidæ have been sent to Mr. R. Senior-White, who has returned them named and is publishing his results, concerning the former group in our *Memoirs* (Vol. VIII, No. 4) and concerning the latter in the *Records of the Indian Museum*. The collection of Culicidæ has received special attention in view of Mr. Edwards' recent revision of the Indian genera and species and in preparation for a *Fauna* volume on the mosquitos of India. A small lot of unnamed or doubtful Culicinæ was sent to Mr. Edwards and has been returned by him. We have also exchanged duplicate specimens with Kasauli. The collection of Culicidæ is now contained in two cabinets and is fairly representative of the Indian fauna. The large mixed collection of Tabanidæ has been gone over and determined as far as possible and arranged properly in cabinets. Many species, which are doubtful or apparently new, are being sent to Major E. E. Austen for identification and description. In view of the possibility that some forms (*e.g.*, *T. striatus*) may really include several species, actually distinct, but externally identical, studies have been made of the genitalia of both sexes of certain Tabanidæ found at Pusa; this mechanism is very complex, especially in the male sex, and the recognition of the different structures and the determination of their functions and homologies require further work. The stem-boring Anthomyiads of the genus *Atherigona* are still with Rao Sahib

Y. Ramachandra Rao, who communicated a paper on these flies to the Fifth Entomological Meeting.

Numerous collections of Indian Insects have been received during the year and named as far as possible. These included collections sent by the Forest Research Institute, the Provincial Departments of Agriculture (including Indian States), the Bombay Natural History Society, and by many correspondents.

VII. Catalogue of Indian Insects.

Due to pressure of other work, less progress can be reported in this line than was anticipated. The second and third parts of the Catalogue, on Culicidæ and Bombylidæ respectively, both by Mr. R. Senior-White, have been published during the year. The card Catalogue of Orthoptera, Neuroptera (*Sensu antiquo*) and Microlepidoptera have been kept up-to-date and parts of the Catalogue on these groups can be issued when the material, now sent out for identification, has been reported on. Card Catalogues of the Apterygota, Thysanoptera, Strepsiptera, and Psyllidæ have been prepared and a good deal of material has been got together in Hymenoptera and Coleoptera. The *Fauna* volumes on Rhynchota have been kept up-to-date. A certain amount of work has also been done on the revision of Macrolepidoptera.

Mr. R. Senior-White has kept up-to-date the card catalogue of Diptera.

Dr. C. Beeson reports, regarding Coleoptera, that the catalogue of Staphylinidæ has been completed by Cameron; of Brenthidæ, by Kleine, is completed but pending inclusion of recent work; of Carabidæ, by Andrewes, is in manuscript but in alphabetical arrangement pending classified arrangement awaiting appearance of another paper; of Bostrychidæ, by Beeson, completed, but pending receipt of recent identifications by Lesne; of Scolytidæ and Platypodidæ, by Beeson, completed, but pending further information; and of Nitidulidæ by Chatterjee, in manuscript.

I have been unable to obtain any information from Mr. Andrewes regarding the preparation of the parts on Rhynchota which he has undertaken.

VIII. Fifth Entomological Meeting.

The Fifth Entomological Meeting was held at Pusa from 5th to 10th February 1923 and was attended by forty-five members and visitors, whilst thirteen others, who could not attend, took part by the contribution of papers. Sixty-one papers, read at the Meeting, were submitted for publication and are included in the Report which is now in the press. A short account of the Meeting was also contributed to the *Agricultural Journal of India* (May, 1923).

IX. Programme of work for 1923-24.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop-pests and especially of the pests of sugarcane, rice and cotton, of fruit-trees and stored grain, and also work on insect pests of domestic animals.

Minor.

Results in various lines require to be written up and published as far as possible; in particular, it is hoped to complete and issue a book on Veterinary Entomology in India. Work and experiments in lac-culture will be continued and new insecticides and insecticidal methods tested as occasion arises. Systematic work will be carried out with our resources and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

X. Publications.

The following publications, either prepared by the Pusa Staff or founded in whole or in part on material sent from Pusa, have actually been issued during the year ended 30th June 1923 :—

Andrewes, H. E. . Notes on Oriental Carabidæ III. (*Ent. Mo. Mag.*, LVIII, 174-179; August 1922.) Notes on Oriental Carabidæ IV. (*t.c.*, 238-240; October 1922.)

Cockerell, T. D. A. . Descriptions and Records of Bees, XCVII. (*Ann. Mag. Nat. Hist.* (9) XI, 263-269; February 1923.)

Dutt, G. R. . . An annotated list of Ichneumonidæ in the Pusa collection. (*Ind. Agri. Ent. Mem.*, VIII, No. 2; April 1923.)

Fletcher, T. Bainbrigge. Agricultural Entomology. (*Ann. Rep. Bd. Sci. Adv. India, 1921-22.*)

,, New names for old. (*Entom.*, LV, 231; October 1922.)

,, List of Publications on Indian Entomology, 1920-1921. (*Pusa Bulletin No. 139;* December 1922.)

,, The Fifth Entomological Meeting. (*Agric. Jour. Ind.;* May 1923.)

Fraser, F. C. . . A second note on Odonata in the Pusa Collection. (*Ind. Agri. Ent. Mem.*, VIII, No. 3; April 1923.)

Hebard, Morgan . Studies in Indian Dermaptera. (*Ind. Agri. Ent. Mem.*, VII, No. 11; February 1923.)

Meyrick, E. . . *Exotic Microlepidoptera*, Parts 17-19.

Misra, C. S. . . The Cultivation of Lac in the Plains of India. (*Pusa Bulletin No. 142;* May 1923.)

d'Orchymont, A. . Hydrophilidæ of India. (*Ind. Agri. Ent. Mem.*, VIII, No. 1; April 1923.)

Prout, L. B. . . New species and forms of Geometridæ. (*Ann. Mag. Nat. Hist.* (9) XI, 305-322; March 1923.)

Uvarov, B. P. . . Rice Grass-hoppers of the genus *Hieroglyphus* and their nearest allies. (*Bull. Ent. Res.*, XIII, 225-241, 3 figs; August 1922.)

REPORT OF THE IMPERIAL AGRICULTURIST.

(Wynne Sayer, B.A.)

I. Administration and Training.

Charge. Mr. G. S. Henderson remained in charge of the farm from 1st July to 6th October, 1922, and from 22nd October, 1922, to 2nd April, 1923. He was on privilege leave from 7th to 21st October and on leave on average pay for 7 months from 3rd April, 1923, when I took over from him in addition to my own duties.

Khan Saheb Mahamad Ikrammuddin, Assistant to the Imperial Agriculturist, acted for the Imperial Agriculturist from 7th to 21st October, 1922. He was on privilege leave combined with furlough for six months from 15th March, 1923. He remained on duty for the rest of the period.

Training. Messrs. Y. G. Krishna Rao and Bachina Ramaiyah, students deputed by Madras Government, completed their one year course in general agriculture on 31st May, 1923.

Mr. T. V. Krishna Swami Rao, a private student from Madras, was admitted to a two years' course in general agriculture on 31st July, 1922.

II. Pusa Farm.

The season June 1922 to May 1923 was distinguished by a rainfall of 65·78 inches as compared with 40·61 inches for the previous season. This was the highest rainfall for the last ten years and its effect on all agricultural operations was very marked.

The actual rainfall in June was 20·56 inches, and as this was heavy and almost continuous sowings were badly hindered, 67 acres of land being finally left unsown. The

germination of all crops sown was very bad; and 90 acres under maize, pulse and other *kharif* crops was completely flooded. A total area of 157 acres was actually under water for about 50 days and the land finally cleared about 8th October. This affected the yield of maize for corn and silage and made a 40 per cent. difference in the green fodder outturn.

A fall of 2·53 inches was recorded in February 1923, which while benefitting all the other *rabi* crops caught *rahar* (*Cajanus indicus*) in flower and considerably decreased the ultimate yield of this crop.

The rainfall figures are given below :—

Month	Rainfall in inches
June 1922	20·56
July 1922	18·32
August 1922	12·72
September 1922	8·33
October 1922	1·30
November 1922	0·00
December 1922	0·66
January 1923	0·03
February 1923	2·53
March 1923	0·00
April 1923	0·30
May 1923	1·03
TOTAL	65·78

Experimental work. 1. The permanent manurial and rotational experiments were continued as before. The results for the year under report are given below :—

TABLE I.

Results of permanent manurial plots for the year 1922-23.

Plot No.	Treatment	A Series			B Series		
		Maize grain per acre	Rahar grain per acre	Barley grain per acre	Maize grain per acre	Oats grain per acre	Peas grain per acre
		lb.	lb.	lb.	lb.	lb.	lb.
1	No manure	422	599	..	560	542	..
2	Farmyard manure to supply 10 lb. nitrogen per acre.	656	636	..	884	755	..
3	Farmyard manure to supply 20 lb. nitrogen per acre.	831	842	..	1,006	992	..
4	Farmyard manure to supply 30 lb. nitrogen per acre.	831	797	..	990	1,061	..
5	Rape cake to supply 20 lb. nitrogen per acre.	706	499	..	700	587	..
6	Sulphate of ammonia to supply 20 lb. nitrogen per acre.	585	402	..	702	389	..
7	Sulphate of potash to supply K_2O as in F.Y.M. No. 3.	426	318	..	506	413	..
8	Superphosphate to supply P_2O_5 as in F.Y.M. No. 3.	709	300	..	782	743	..
9	Sulphate of potash to supply K_2O and superphosphate to supply P_2O_5 as in F.Y.M. No. 3.	569	238	..	470	760	..
10	Sulphate of ammonia to supply nitrogen and sulphate of potash to supply K_2O and superphosphate to supply P_2O_5 as in F.Y.M. No. 3.	494	88	..	705	883	..
11	No manure or leguminous crop .	325	..	279	159	398	..
12	Green manure in a cereal rotation.	735	2	255	..	712	..
13	Deep-rooted leguminous crop in a cereal rotation.	453	302	..	493	480	..
14	One deep, one shallow-rooted legume in the rotation.	527	343	..	601	443	92
15	Leguminous crop and green manure in the rotation.	1,224	330	..	..	998	..
16	Green manure and superphosphate to supply P_2O_5 as in F.Y.M.No.3.	1,561	431	..	..	1,948	..

2. The green-manuring experiments run in collaboration with the Imperial Agricultural Bacteriologist were conti-

nued. The treatment and the outturns are shown in the following statement. The results are dealt with by the Imperial Agricultural Bacteriologist in his report.

TABLE II.

Results of green-manuring series for the year 1922-23.

Plot No.	Treatment	Oats grain per acre in lb.
21 B	Three times sann-hemp fermented without superphosphate. Sann-hemp in Kharif 1917.	1,326
22 B	Three times sann-hemp fermented with 3 cwt. superphosphate per acre in Kharif 1917.	1,846
23 B	Not in experiment	983
24 B	Control	1,501
25 B	Sann-hemp ploughed in without superphosphate in Kharif 1917.	1,137
26 B	Superphosphate alone at 3 cwt. per acre without giving manure before oats sowing in Rabi 1917-18.	1,700
27 B	Control	1,698
28 B	Not in experiment	2,129
29 B	Six times sann-hemp fermented without superphosphate in Kharif 1917.	1,476
30 B	Six times sann-hemp fermented with 3 cwt. superphosphate per acre in Kharif 1917.	2,187
31 B	Control	1,796
32 B	Sann-hemp ploughed in with 3 cwt. superphosphate per acre in Kharif 1917.	1,766

Note. Sann-hemp ploughed in in Kharif 1921 in all the plots.

3. The experiments for comparison of the economic value of the common leguminous crops, both for green fodder and grain, were carried out on a series of fairly uniform $\frac{1}{4}$-acre plots. The varieties and yields obtained are shown in the following statements.

TABLE III.

Comparative yield of kharif pulses on $\frac{1}{4}$-acre plots.

Variety	Outturn of green fodder per acre in lb.	Outturn of grain per acre in lb.
Guar (*Cyamopsis psoraloides*)	6,693·0	1,141·5
Velvet beans	9,998·5	1,431·0
Soy beans	6,151·5	1,701·0
Math (*Phaseolus aconitifolius*)	10,532·5	1,588·0
Urid (*Phaseolus radiatus*)	10,265·5	343·0
Cowpeas	8,828·5	491·0

Guar stands flooding better and is less liable to disease. Hence though a smaller yielder, it is extensively grown on the farm.

TABLE IV.

Comparative yield of rabi pulses on $\frac{1}{4}$-acre plots.

Variety	Outturn of grain per acre in lb.
Gram Pusa 23	1,515
„ Pusa 25	1,915
„ Pusa 6	1,610
„ Pusa 17	1,854
„ big Kabuli	1,572
„ small Kabuli	956
„ Pusa Local	1,162
„ Common yellow of Gujarat	997
„ Cawnpore Local	1,352
Peas big white	930
„ small (Kerao)	1,304
Khesari (*Lathyrus sativus*)	737
Val (*Dolichos Lablab*)	926
Masoor (*Lens esculenta*)	460

These varietal tests are for testing out and comparing the pedigreed varieties which have been selected or evolved with those varieties being grown locally, and the results show that the pedigreed varieties can be depended upon to give a high yield.

4. Manurial experiments with monocalcic phosphate and calcium sulphate in conjunction with green manure were carried out for the Imperial Agricultural Chemist. The crop outturn and treatment are shown in Table V.

TABLE V.

Plot No.	Area in acre	Treatment	Normal outturn of oats grain in lb. per acre	Yield after treatment in lb. per acre
15 D	0·25	Monocalcic phosphate applied at the time of ploughing in sann-hemp at 54 lb. per acre.	1,654	1,946
19 D	0·25	Calcium sulphate applied at the time of ploughing at 64 lb. per acre.	1,636	887

5. Experiments with various chemicals to deal with crop diseases were continued for the Fibre Expert and the Imperial Mycologist.

6. Experiments were started with the Supernumerary Agricultural Chemist to test the effect of varying irrigations and application of nitrate of soda on the yield and quality of wheat. The results will be dealt with by that officer.

7. A large number of cereals have been received from different parts of the world. They are at present in process of acclimatization. Some give promise of proving really valuable, such as New Zealand white oats, Scotch potato oats, Captain oats and New Ascot white oats.

General farming. The major portion of the total cultivated area of the farm is run as a fertility experiment on a large scale to provide data for practical farming. Com-

bined with this we have power cultivation, rotation work and intensive cattle feeding. It is worked under a 3-year 6-course fixed rotation as given below :—

	1st Year	2nd Year	3rd Year
Monsoon (Kharif) crop .	Maize for silage and green fodder manured with farmyard manure at 10 tons per acre or oil-cake.	Maize for corn with *rahar*. No manure.	Leguminous crops for soiling.
Winter (Rabi) crop .	Oats.	*Rahar* stands on .	Oats after application of 1 md. superphosphate per acre.

. The figures of outturn of this experiment (area 413 acres) for the last 11 years are shown in the following table.

TABLE VI.

Yield from 13 fields at Pusa (413 acres) for 11 years.

Year	Oats and other cereals	Maize	Pulses	Total grain	Green stuff for fodder and silage
	mds	mds.	mds.	mds.	mds.
1912-13	2,210	522	894	3,626	16,301
1913-14	1,997	200	1,100	3,297	11,518
1914-15	1,749	534	704	2,987	14,427
1915-16	2,669	884	701	4,254	36,903
1916-17	2,897	670	932	4,499	31,971
1917-18	2,376	1,276	1,010	4,662	30,893
1918-19	3,386	559	1,037	4,982	30,735
1919-20	2,479	1,064	719	4,262	31,624
1920-21	2,542	766	1,073	4,381	33,359
1921-22	3,754	1,267	1,132	6,153	34,492
1922-23	3,752	496	941	5,189	23,021

The drop in the yields of the year under report compared to previous years is due to the heavy rainfall which resulted in an almost total failure of the *kharif* crop. The yield

of maize and *rahar* was severely affected. Oats did well, the maximum outturn per acre being $23\frac{1}{2}$ maunds over 20 acres from Mysore field, as against 20·9 maunds in the Brickfield which was last year's maximum. The average yield was 18 maunds over 210 acres as against 17 maunds per acre over 218 acres last year. The total production of the farm from the rotational and non-rotational area as compared with season 1921-22 is given below :—

TABLE VII.

Total farm produce during 1921-22 and 1922-23.

Year	Grain	Green fodder	Dry *bhusa*
	mds.	mds.	mds.
1921-22	7,060	41,925	14,000
1922-23	6,560	32,952	12,000

The value of the total produce grown, calculated at current market rates, is about Rs. 56,000, including the value of 90 acres pulse crop grazed by the cattle on the land and 40 acres *berseem* (*Trifolium alexandrinum*) grazed four times.

The large and valuable herd maintained on the farm is practically completely supported by farm produce, the only thing bought in being oil-cake. A constant supply of green fodder has now been made available throughout the year, and though in the year under report this was short of normal by 40 per cent., yet we have been able to carry over 3,000 maunds of silage surplus to this year. This shows that the farm is now entirely self-supporting in this respect and the milch herd can now be maintained at full strength on a green fodder ration throughout the year—a great advance in the question of milk production.

Waste dhab land and berseem. In order to solve the problem of supplying green fodder for the herd through-

out the whole year, the work of bringing waste *dhab* land under the plough was taken in hand in January 1920. At the close of the year under report 60 acres of this waste land which was very uneven has been cleared, levelled and completed for irrigation. All the levelling has been done by means of bullock drawn scrapers at minimum cost as this work was done when the farm cattle were "standing off". Forty acres of this levelled land were sown under *berseem* in last cold weather. Sowing started in the middle of October and was finished by the 13th of November. The cattle in the breeding herd were put on the crop on 29th November and four grazings were taken from that date, about 200 head of cattle being on the *berseem* day and night. Grazing finally finished at the end of May. 2,000 maunds of *berseem* was cut by hand for bullocks, and ten acres reserved having failed to set seed was finally grazed. The average daily milk yield of the milch herd, while this crop was being grazed, went up from 11 lb. to 13·6 lb. per cow. The outturn as estimated from the harvested plots came to 125 maunds per acre per cut. After the last grazing the land was sown in maize, which crop started supplying green fodder on 4th May and continued to supply about 150 maunds daily to 400 head. The crop outturn was about 300 maunds green fodder per acre, one silo pit of 3,500 maunds taking the surplus from this crop at break of monsoon. (Plate II.)

The area under first year rotation is mainly taken up with maize and *jowar* (*Andropogon Sorghum*) grown for silage of which about 20,000 maunds is made every year. At first tower silos were used, but they proved thoroughly unsatisfactory, the waste due to the impossibility of consolidating silage properly being as high as 40 per cent. For the last 5 years 6 pit silos ($50' \times 10' \times 8'$) have been in use, each holding about 3,500 maunds. The green stuff to be run through the silage cutter is weighed in and the silage weighed out when fed. Wastage has averaged 15 per cent. Maize has been found the most suitable crop for the silage and no difficulty is experienced in getting cattle to eat it.

MAIZE AFTER BERSEEM IN DHAB LAND.

III. Machinery.

Steam ploughing tackle. All ploughing work and the subsequent heavier operations were done by the steam ploughing tackle. The set worked during the year for 112 days of 10 actual working hours. The engines were, however, used for threshing, pumping and silage cutting when there was no cultivation work. Working costs and the analysis for different operations are shown in the following two comparative statements; but, as usual, until it is possible to work the tackle full time, incidental and replacement expenses are bound to bulk high on the acreage done. A tackle set of this class should under optimum conditions be working every day when the land is not too wet, and this would result in a material reduction of overhead charges per acre worked per annum.

Table VIII.

Showing cost of working the steam tackle for last five seasons.

Particulars	1918-19	1919-20	1920-21	1921-22	1922-23
	No. of working days 145	No. of working days 126	No. of working days 131	No. of working days 114	No. of working days 112
	Rs.	Rs.	Rs.	Rs.	Rs.
Labour	934	1,200	1,450	1,243	1,278
Fuel	1,656	1,623	2,140	1,622	1,464
Oil	482	633	588	412	483
Miscellaneous stores, etc., and renewals	1,064	1,196	1,764	1,783	2,137
Total .	4,136	4,652	5,942	5,060	5,362

TABLE IX.

Showing the above cost divided into different operations per acre for last five years.

	1918-19			1919-20			1920-21			1921-22			1922-23		
	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work	Total area cultivated in the year	Cost per acre	Best day's work
	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres	Acres	Rs.	Acres
Ploughing . . .	373·5	3·9	7·5	404·5	4·8	7·5	445	6·0	7·5	241·5	5·6	7·8	373·0	5·51	8·34
Disc harrowing . . .	605·5	1·7	16·5	582·0	1·7	20·5	633	2·5	17·5	442·0	2·6	16·5	470·0	2·81	16·50
Grubbing	668·0	1·4	20·5	488·0	1·6	22·0	480	2·0	22·0	600·5	2·0	21·3	507·0	2·25	21·00
Rolling . . .	540·0	1·3	21·0	533·0	1·6	23·0	386	1·8	25·0	285·0	2·0	21·0	333·5	2·06	23·00
	2,187	..	..	2,007·5	..	..	1,944	..	..	1,569	..	..	1,683·5	..	..

Cultivation by motor tractors. The following tractors were under test throughout the year :—

Three Austins. One Fordson.	Four-wheel type.
One Cletrac.	Caterpillar tread.

One Austin was a total wreck from the beginning of the year; the other two and the Fordson worked intermittently, being constantly laid up for repairs. In the case of the Austins the delay in getting spare parts was again most noticeable, and considerable delay was also experienced in this connection with the Fordson. The hopelessness of trying to popularize any tractor whose spare parts are only obtained with difficulty may possibly by this time have penetrated to the makers in England. I can only again affirm that this state of things will assuredly ultimately kill the motor tractor trade in India. As waiting for 6 months for an essential part is neither business nor pleasure.

The Cletrac whose cylinders are badly scored did not work at all during the year under report. The remarks of the Imperial Agriculturist in the report of 1919-20 regarding agricultural machinery still hold good. Both Austin and Fordson types are too light and too low powered for deep ploughing. They are extremely useful for light and shallow cultivation with disc harrows or cultivators and cover large areas in a working day, and after inclement weather when a large area of land has to be dealt with for *rabi* sowing in the minimum time they are invaluable, but here again the question of spare parts appears and the liability to " break-down " and subsequent " hold-ups " through failure to obtain essential parts rapidly takes away very considerably from the advantages enumerated above. The maintenance of a complete supply of spare parts with the tractor is the only apparent solution, and this is a considerable expense to the owner of a solitary tractor.

Among other machinery, the International and Climax silage cutters were under trial and improvement was

brought to the notice of the makers. An all-steel thresher and several types of ploughs and cultivators are being tested and improvements and alterations are under consideration.

IV. Cattle.

The herds during the year under report numbered as under :—

Montgomery	181
Cross-bred	121
	302

The year was marked by a couple of outbreaks of foot-and-mouth in August 1922 and March 1923. In the first attack both our Ayrshire bulls, Lessnessock Wildfire and Whitehill Topnotcher, went out, and in the second attack we had a very high mortality among the pail-fed calves, losing about 19 in a short time. Although the milk production of the herd was not affected to any great extent, due to there being a constant and sufficient supply of green food throughout the year, yet the effects of the two outbreaks are shown in the fact that a large percentage of the cows have reverted, and considerable delay is now experienced in getting the female stock to hold, this possibly being due to weakness on either side, the latent effects of the outbreaks.

Ninety-one head were inoculated by the serum simultaneous method against rinderpest in February, Mr. Bennett, Second Bacteriologist from Muktesar, officiating. The inoculation was quite successful : only one virus producer being lost. The arrangements this year were very simple, and in place of the usual camp, all cattle were placed in the Chanman shed. This resulted in the inoculation being conducted in a much cheaper way and being quite as effective as in former years.

A double cross heifer (F_2 generation) No. 66 was tested back for immunity by inoculation with 15 c.c. of defibrinated virulent blood subcutaneously. She was inoculated by the serum simultaneous method in December 1920, and the subsequent dose of virulent blood in February 1923 produced no effect whatever, thus definitely proving the active immunity of cattle once inoculated by the serum simultaneous method.

All our stock have been immunised by this method, and this result proves that the herd can face all outbreaks of rinderpest in the district with equanimity.

Half-bred cow Alibi No. 3 completed her fifth lactation with 1,200 gallons in 300 days. She has calved again on 12th July, 1923. As she is now $8\frac{1}{2}$ years old, this probably represents her best performance.

We have now 4 $\frac{3}{4}$-Ayrshire, 4 $\frac{1}{4}$-Ayrshire and 4 double crosses (F_2), but none of these appear very promising so far. The effect of the heat is very noticeable in the case of the majority of the $\frac{3}{4}$-bred, and it is evident that this will militate heavily against them as milk producers, and they will only do really well at higher altitudes.

The surplus milk of the herd is now being marketed in neighbouring stations where there is a great demand, and the real value of the herd is being shown in the milk receipts in competition with the ordinary milk supplied in these stations at current rates.

Cattle to the value of Rs. 6,227 were sold during the year.

Tables showing (1) the milk yield during the year, (2) concentrated food and fodder consumed, (3) milk disposed of, and (4) the number of cows in milk and dry during 1922-23, are given below and demonstrate the lines on which the herd is run.

Table X.

Showing the milk yield during the year 1922-23.

Month	Total yield		Cross-bred cows		Montgomery cows	
	No. of cows in milk	Milk in lb.	No. of cows in milk	Milk in lb.	No. of cows in milk	Milk in lb.
July 1922	72	29,271	32	17,417	40	11,854
August	71	27,357	31	15,469	40	11,888
September	72	23,485	30	12,301	42	11,184
October	70	23,994	30	12,646	40	11,348
November	71	24,141	27	12,056	44	12,085
December	72	27,044	27	14,002	45	13,042
January 1923	82	31,987	32	18,372	50	13,615
February	90	32,849	37	18,439	53	14,410
March	87	36,803	36	19,611	51	17,192
April	88	33,986	36	17,388	52	16,598
May	92	32,288	36	15,741	56	16,547
June	90	27,711	35	12,971	55	14,740
	957	3,50,916	389	1,86,413	568	1,64,503

Table XI.

Showing the consumption of concentrated food by the breeding herd during 1922-23.

Month	Oats	Maize	Chuni	Oilcake	Salt	Barley	Coarse rice
	m. s. c.	m. s. c.	m. s. c.	m. s. c.	m. s. c.	m. s. c.	m. s. c.
July 1922	284-34-14	..	86-21-6	62- 9-8	10-28-4	..	..
August	291- 1-0	..	79-37-10	39-27-10	11-26-6	..	..
September	238-13-12	30-19-8	73- 5-0	36-28-12	11-13-11	..	0-10-0
October	178-14-4	94-17-0	72-19-4	37-38-2	11- 6-6	..	..
November	161- 3-8	93-29-4	62-36-8	47-39-4	10- 9-14	..	..
December	85-38-4	176-22-12	59- 5-12	63-28-12	10-19-13½	..	0- 7-0
January 1923	136-29-14	113-39-0	73- 4-12	63-26-6	9-28-7½	..	..
February	211- 7-0	..	91-14-0	55- 7-8	10- 6-13	..	0-20-0
March	221-37-2	..	120-26-2	63-16-0	8-36-0	..	0-25-0
April	190- 4-12	..	114-30-0	57-23-12	9- 7-6	23- 9-0	0-15-0
May	169-15-14	..	108-31-0	65-21-0	9-33-2	55-30-8	..
June	174-35-0	..	84-22-12	59- 8-4	9-20-9	42-30-8	..
	2,343-35-4	509- 7-8	1,027-14-2	652-34-14	122-36-12	121-30-0	1-37-0

TABLE XII.

Showing the consumption of fodder by the breeding herd during 1922-23.

Month	Bhusa	Silage	Green maize kutti	Guar	Math	Berseem	Green oats and peas	Turnip
	mds.	mds.	mds.	mds.	mds.	mds.	mds.	m. s. c.
July 1922	277	150	2,373	..	..	..	..	..
August	431	..	339	892	6	..	..	.
September	467	..	563	199	366	..	..	..
October	447	1,423	180	..	..	..	..	..
November	369	2,303	..	..	..	..	..	..
December	305½	2,070	..	..	..	16¾	..	94-23-0
January 1923	238	1,001	..	..	..	..	351	118-12-0
February	187½	61	..	..	..	150	981	..
March	147	540	..	..	..	120	330	..
April	318	410	..	..	..	330	..	..
May	699½	..	1,022	..	..	47	..	..
June	862	..	1,538½	..	..	..	..	..
For inoculation camp	..	427	..	..	..	..	..	..
	4,748½	8,385	6,015½	1,091	372	663¾	1,662	212-35-0

Table XIII.

Showing disposal of milk in lb. during the year 1922-23.

Month	MILK													Cream in oz.
	Total yield.	Sold at the rate of					Issued for						Grand total	
		25 lb.	16 lb.	12 lb.	10 lb.	Total sales	Cream	Butter or ghee	Analysis	Fed to calves	Miscellaneous disposal	Total		
July 1922	29,271	19,585	..	..	..	19,585	2,433	524	5	6,273	451	9,686	29,271	2,905
August	27,357	18,168¾	..	..	..	18,168¾	1,707	48	11	6,737	685½	9,188½	27,357	2,021
September	23,485	14,995½	..	..	..	14,995½	1,241	21	6	6,757	464½	8,489½	23,485	1,550
October	23,994	16,553	..	..	..	16,553	1,540	..	10	5,557	334	7,441	23,994	2,025
November	24,141	..	15,243¼	..	..	15,243¼	2,593	513	6	5,227	558¾	8,897¾	24,141	3,263
December	27,044	..	16,593	..	..	16,593	3,297	133	9	6,704	308	10,451	27,044	3,989
January 1923	31,987	..	17,852½	583	661½	19,097	3,088	1,230	4	8,225	343	12,890	31,987	3,462
February	32,849	..	16,843½	799	1,109½	18,752	3,480	1,215	9	9,103	290	14,097	32,849	3,843
March	36,803	..	16,220	1,294½	3,639	21,153½	2,921	2,503	6	9,883	336½	15,649½	36,803	3,029
April	33,986	..	15,722½	3,613	3,740½	23,076	2,350	1,455	55	6,743	307	10,910	33,986	2,550
May	32,288	..	15,279½	6,180	2,732	24,191½	1,424	80	62	6,238	292½	8,096½	32,288	1,688
June	27,711	..	14,119	4,225	2,630	20,974	1,594	..	60	4,953	130	6,737	27,711	1,805
	3,50,916	69,302½	1,27,873½	16,694½	14,512½	2,28,382½	27,668	7,722	243	82,400	4,500½	122,533½	3,50,916	32,301

TABLE XIV.

Showing the percentage of cows in milk and dry during 1922-23.

Month	CROSS-BRED COWS				MONTGOMERY COWS MILKED WITHOUT CALF				MONTGOMERY COWS MILKED WITH CALF			
	Total No. of cows	In milk	Dry	Percentage in milk	Total No. of cows	In milk	Dry	Percentage in milk	Total No. of cows	In milk	Dry	Percentage in milk
July 1922	41	32	9	78·0	46	26	20	56·5	30	14	16	46·6
August	42	31	11	73·8	44	27	17	61·3	30	13	17	43·3
September	45	30	15	66·6	45	27	18	60·0	30	15	15	50·0
October	43	30	13	69·7	49	26	23	53·0	29	14	15	48·2
November	44	27	17	61·3	53	28	25	52·8	28	16	12	57·1
December	46	27	19	58·6	56	33	23	58·9	28	12	16	42·8
January 1923	46	32	14	69·5	57	34	23	59·6	28	16	12	57·1
February	46	37	9	80·4	57	37	20	64·9	27	16	11	59·2
March	47	36	11	76·5	56	37	19	66·0	27	14	13	51·8
April	48	36	12	75·0	57	38	19	66·6	27	14	13	51·8
May	48	36	12	75·0	57	40	17	70·1	27	16	11	59·2
June	48	35	13	72·9	59	41	18	69·4	27	14	13	51·8

Table XV.

Showing the average milk yield (in lb.) per cow per day for 10 years (1913-14 to 1922-23).

Year	July			August			September			October			November			December		
	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day
1913-14	50	328	6·5	49	307	6·2	48	296	6·2	47	273	5·8	49	265	5·4	47	233	5·0
1914-15	40	306	7·6	39	317	8·1	42	304	7·2	43	296	6·9	45	288	6·4	43	317	7·4
1915-16	47	357	7·6	47	368	7·8	47	352	7·5	48	340	7·1	49	374	7·6	47	355	7·5
1916-17	51	365	7·1	54	342	6·3	52	295	5·6	54	282	5·2	53	259	4·8	51	300	6·0
1917-18	72	532	7·4	70	441	6·3	62	430	7·0	65	407	6·0	65	416	6·4	66	465	7·0
1918-19	57	504	8·8	62	550	8·9	63	516	8·2	63	432	6·8	62	385	6·2	53	291	5·5
1919-20	79	689	8·7	78	731	9·3	68	681	10·0	69	578	8·3	64	545	8·5	62	530	8·5
1920-21	70	769	11·0	72	734	10·2	80	766	9·5	75	632	8·4	70	564	8·0	76	695	9·1
1921-22	98	1,080	11·0	108	1,025	9·5	104	900	8·6	100	789	7·9	90	733	8·1	87	838	9·6
1922-23	72	944	13·1	71	883	12·4	72	783	10·9	70	774	11·0	71	804	11·3	72	872	12·1

TABLE XV—*concld.*

Showing the average milk yield (in lb.) per cow per day for 10 years (1913-14 to 1922-23)—concld.

Year	JANUARY			FEBRUARY			MARCH			APRIL			MAY			JUNE		
	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day	No. of cows in milk per day	Yield per day	Yield per cow per day
1913-14	51	252	4·9	52	265	5·1	49	266	5·4	50	313	6·2	49	306	6·2	42	296	7·0
1914-15	45	334	7·4	46	348	7·5	48	349	7·3	45	370	8·2	42	350	8·3	41	332	8·1
1915-16	49	377	7·7	55	477	8·7	64	598	11·0	56	558	9·9	59	504	8·5	55	501	9·1
1916-17	53	373	7·0	59	449	7·6	66	507	7·6	74	531	7·2	71	500	7·0	62	509	8·2
1917-18	67	496	7·4	65	533	8·2	63	557	8·8	52	494	9·5	52	455	8·7	52	469	9·0
1918-19	68	391	5·7	77	522	6·8	84	560	6·6	89	653	7·3	86	603	7·0	79	687	8·7
1919-20	60	592	9·9	58	576	9·9	68	632	9·3	67	779	11·6	62	721	11·6	64	704	11·0
1920-21	77	785	10·2	87	1,007	11·5	94	1,182	12·6	102	1,287	12·6	102	1,228	12·0	95	1,059	11·1
1921-22	85	941	11·0	89	1,061	11·9	77	918	11·9	75	920	12·2	72	988	13·7	74	1,009	13·6
1922-23	82	1,031	12·6	90	1,173	13·0	87	1,187	13·6	88	1,132	12·8	92	1,041	11·3	90	923	10·2

NOTE.—This statement clearly shows the progress made by the herd on the all important question of milk production in the last ten years.

From Table XV the progress made by the herd can clearly be seen. The improvement in the Montgomery section is most clearly marked and the average yield of first calf heifers brought in is steadily rising. The cross-bred section remains steady. We started by producing three first class cows out of the first six bred, and this record is hard to live up to. Many of the young cows which at first did not do brilliantly are now improving and showing every sign of becoming 7,000 lb. cows.

V. Programme of work for 1923-24.

1. (*a*) Practical treatment of pedigree dairy herd of Indian cattle and pedigree dairy herd of Montgomery-Ayrshire cattle.

(*b*) Continuance of experiments with regard to fixing a type of Montgomery-Ayrshire most suitable to Indian conditions.

2. Practical treatment of a 1,200-acre mixed farm with particular attention to profitable modern machinery and the financial result of the work.

The bulk of the produce of the Pusa Farm is used for the maintenance of the dairy herd. The rotation adopted aims at the up-keep of the fertility of the land along with supply of concentrated food and long fodder and a constant supply of green fodder throughout the year. Included in the above is the study on a practical scale of :—

(*a*) Rotations.

(*b*) Crops for fodder, seed and silage.

(*c*) Implements and machinery.

(*d*) Technique of cultural operations.

3. Continuation of collection of data and results regarding the costs and capabilities of the steam-ploughing tackle on estates of this size.

4. Experiments with various types of motor tractors and ploughs for collection of data and working costs and

for determination of most suitable types of tractors and implements for India. Also collaboration with manufacturers regarding the manufacturing and introduction of improvements in standard types to suit Indian conditions.

5. *Experimental work at Pusa.*

(*a*) Rotational experiments.

(*b*) Trial of new varieties of crops especially leguminous fodder crops and wheat varieties.

(*c*) Manurial experiments, especially seasonal and quantitative tests with phosphates.

(*d*) Seasonal tests with Java and Sumatrana indigo.

(*e*) Trial of sugarcane varieties suitable for growth without irrigation, along with the Sugar Bureau.

6. Demonstrations, exhibitions and sales of surplus dairy stock, etc., will be held from time to time as occasion offers.

7. *Touring and advisory.* Visits will be paid to provincial agricultural centres. This should tend to co-ordination of agricultural work.

REPORT OF THE IMPERIAL DAIRY EXPERT.

(W. Smith.)

During the year under review, no facilities for the giving of dairy education or for practical experimental or research work were provided and the work done was consequently purely of an advisory character, and may be divided into four headings: (1) Work done for Local Governments, Indian States, municipalities, etc.; (2) Advice and assistance given to the general public in India: (3) Work done for persons or Governments outside of India; and (4) General.

I. Work done for Local Governments, Indian States, Municipalities, etc.

Burma. Arrangements were made for the practical training of three Indian officers for the Government of Burma at one of the military dairy farms, and suggestions were made to this Government regarding the most suitable manner of utilizing the grant allotted this year for the establishment of a model dairy farm and school in connection with the Mandalay College.

Three Sindhi cows were selected and shipped from Karachi and a pedigreed Ayrshire bull was procured from Europe for the Maymyo Town Committee.

Copies of the trading accounts of certain Government dairies in India were supplied to the Veterinary Officer to the Corporation of Rangoon at his request.

Madras. I attended a conference at Bangalore in July 1922 at which the subject of cattle breeding experiments then being carried out at the military dairy farm, Bangalore, for the Madras Government were discussed with the Deputy Director of Agriculture, Live Stock, Madras, and the Assistant Controller, Military Dairy Farms, 3rd Circle. This conference submitted a unanimous report to

the Government of Madras. From Bangalore I visited Ootacamund at the request of the Director of Agriculture, Madras, and later on submitted, in conjunction with the Deputy Director of Agriculture, Live Stock, Madras, a complete scheme with building plans, machinery specifications, cost statements, estimated trading accounts, etc., for the establishment of a municipal dairy at Ootacamund. The details and points of this scheme were discussed with the Director of Agriculture, Madras, after visiting Ootacamund, and before submission of the scheme.

Bombay. I had the privilege of addressing the students of the Agricultural College, Poona, on the importance of the development of the cattle breeding and dairying industries in this country, and about the same date I gave evidence before the Cattle Committee appointed by the Government of Bombay to report on cattle breeding in that presidency. I attended a meeting at the office of the Director of Agriculture, Bombay, in August 1922 when the question of the establishment of a modern dairy college by the Government of Bombay at the military dairy farm, Kirkee, was discussed, and as the result of this meeting a specification of the necessary extra equipment required to make the military dairy farm at Kirkee suitable as an educational institution was submitted to the Director of Agriculture, Bombay.

In November 1922, I visited Sind and, in communication with the Chief Commissioner and Deputy Director of Animal Breeding, Bombay, drew up a report, for the Government of Bombay, dealing with the question of cattle breeding and dairying in Sind. Later, plans of a cattle shed and other dairy buildings for the Willingdon Cattle Farm in Sind, and cattle shed plans for a temple dairy in Gujarat, were supplied to the Deputy Director, Animal Breeding, Bombay.

Accompanied by the Agricultural Adviser to the Government of India, I again visited Sind in April 1923 at the request of the Director of Agriculture, Bombay, and along with the Agricultural Adviser to the Government of

India, the Deputy Director of Agriculture in Sind, and the Deputy Director of Animal Breeding, Bombay, signed a unanimous report concerning the working of the Willingdon Cattle Farm at Karachi and the general question of cattle breeding in Sind.

During the year under review no less than five different schemes were drawn up in this office for the improvement of the milk supply of Bombay. These schemes were :—

(1) Scheme for the erection and working of cattle stables in Bombay.

(2) Scheme for Mr. R. S. Patel, for the establishment of a dairy at Bulsar with a depôt in Bombay.

(3) Scheme for Khan Bahadur Bhiladvala for establishment of a dairy at Talegaon with a depôt in Bombay.

(4) Scheme consolidating (2) and (3) as above to be worked by a limited company subsidised by the Corporation of Bombay.

(5) Scheme for the establishment of a municipality owned and managed dairy in substitution of item (4) above.

All of these schemes were complete with building plans, machinery specifications, estimates of cost, and estimated profit and loss accounts, and entailed considerable time and labour. Frequent visits were made to Bombay in connection with these schemes and matters were discussed personally with the Municipal Commissioner and the Dairy Superintendent of the Corporation of Bombay. Finally, I personally attended a meeting of the Sanitary Measures Committee of the Corporation which deals with such matters. Up to the present no definite steps to carry out any of these schemes have been taken notwithstanding the eagerness of the Municipal Commissioner, the Health Officer of the city and the Dairy Superintendent of the Corporation to tackle this question.

The milk supply of Bombay is probably the worst and the most expensive of any large city in the world, and the

death rate of infants up to one year old is 66 per 100—an appalling figure.

I strongly recommend a subsidised private company as being likely to be the most efficient and most extensive way of solving the problem, but failing this a Corporation owned dairy farm working under proper conditions would be better than nothing.

In September 1922, I gave a lecture in Bombay, under the auspices of the Servants of India Society, on the importance of milk production as a factor in Indian cattle breeding, to the members of the Central Co-operative Institute and others.

Central Provinces. I addressed a public meeting organized by the Agricultural Department of the Government of Central Provinces at Nagpur in March on the importance of the development of the dairy industry in India. The Minister of Agriculture, Central Provinces Government, took the chair at the meeting, and His Excellency the Governor was present.

Plans for new cattle sheds and specifications of new dairy plant were furnished to the Agricultural Department of this province, and six Sahiwal heifers and two pedigreed Sahiwal bulls were selected and purchased for the Deputy Director of Agriculture, Live Stock, Nagpur, from the military herds at Lahore and Ferozepore.

United Provinces. Two lectures on technical dairy subjects, illustrated by modern cinematograph films, were given to the students of the Agricultural College at Cawnpore, and the necessity of providing modern equipment for the college dairy was placed before the Director of Agriculture. Frequent advice regarding the management of the dairy herd at the Cawnpore college has been given to the Agriculturist-in-charge.

Bengal. On the occasion of the visit of the Hon'ble Member for Revenue and Agriculture to Calcutta in March, I had the privilege of introducing to him a number of prominent Marwaris interested in the milk problem

in that city, with whom he discussed the question of improving the milk supply of the city; and during the year I have been in correspondence with the Director of Agriculture concerning dairying and cattle breeding matters. I have arranged to visit the cattle breeding farm of the Government of Bengal at Rangpur at an early date to advise regarding its future policy.

Certain stud bulls owned by the Corporation of Calcutta were inspected by me and a report as to their feeding and treatment submitted to the Corporation.

Bihar and Orissa. I have been in touch with the Director of Agriculture of this province throughout the year, and advice has been given concerning the drafting of regulations for the control of milk supply in cities and on other dairy matters.

Punjab. At the request of the Director of Agriculture, Punjab, I made a number of visits to the dairy farm concession granted by the Punjab Government to Mrs. Brown's syndicate. I supplied this syndicate with a complete set of building plans and machinery specifications for the modern dairy they are required by the terms of the lease to erect on the lands, and the buildings have been inspected twice whilst in course of erection. I have undertaken to assist this company in the selection of their foundation milking stock, to pass the dairy machinery now on order for this dairy when erected and to give technical advice whenever required.

The Director of Agriculture, Punjab, asked me to advise him concerning a dairy scheme submitted to him for the supply of milk to the town of Sirsa, and in March I inspected the proposed site and submitted a report on the project to the Director of Agriculture with complete building plans, etc.

On the invitation of the Principal of the Agricultural College at Lyallpur I gave two lectures on technical dairy subjects to the students of this college, both of which were illustrated by modern cinematograph films illustrating

modern dairy practice; and I also gave a public cinematograph lecture in the Young Men's Christian Association Hall, Lahore, on the importance of the milk problem from a public health point of view.

Amended machinery specifications for the equipment of the college dairy at Lyallpur were supplied to the Principal.

Assam. Certain particulars regarding cross-bred cattle were supplied to the Deputy Director of Agriculture, Surma Valley.

Baroda State. I visited Baroda State in July 1922, and in company with various State officials including the second Prime Minister, Mr. C. N. Seddon, I inspected the proposed dairy site and the new cattle sheds under construction. I have been in correspondence with the Agricultural Department of this State throughout the year and have advised frequently on matters connected with dairying and cattle breeding.

Dewas (Junior) State. I visited this State in August 1922, and after discussing cattle breeding and dairying matters with His Highness the Maharaja and the Dewan of the State submitted a scheme including building plans, estimates of costs, etc., for the establishment of a cattle breeding farm near the State capital.

Gwalior. Correspondence took place with the animal husbandry department of this State, and advice on technical subjects was given.

Travancore State. Twelve Sindhi cows were selected, tested and shipped to the Director of Agriculture, Travancore State.

II. Advice and Assistance given to general Public in India.

Plans for new dairy buildings for Edw. Keventer, Ltd., at Raisina, are in preparation in my office and will shortly be completed.

The firm of Syed A. & M. Wazir Ali of Lahore have been supplied with technical information concerning the manufacture of tinned sterilized milk, condensed milk, dried milk, etc., and as soon as this firm can obtain suitable lands detailed plans and specifications will be furnished to them. Negotiations are in progress with the Punjab Government on behalf of this firm with a view to their obtaining suitable lands.

I inspected the model dairy farm of the Tata Iron & Steel Co., Ltd., at Jamshedpur, and discussed with the Town Commissioner and the General Manager the probability of this company's completely controlling the milk supply of the town of Jamshedpur.

Building plans showing position of machinery, etc., for a proposed model dairy at Kamshet were supplied to Mr. M. D. Darookhanavala, Bombay, and general advice was given to him regarding the working of his proposed farm with special figures concerning cost of milk production in India.

Thirty-four cows and two bulls were selected and railed to the Allahabad Agricultural Institute, and some thirty Sindhi milch cattle and one pure bred Ayrshire bull were selected and despatched to various private individuals in Burma during the year under review.

In addition to the foregoing, some thirty individuals or firms in various parts of India applied for information concerning dairying or cattle breeding and in all cases all possible assistance was given to applicants.

III. Work done for Governments or persons outside of India.

The work done for Governments or persons outside of India during the year included the selection and shipment of four bulls and seventeen cows for the Government of Mauritius, the selection and shipment of two buffalo bulls and two buffalo cows to the Island of Trinidad in the West Indies, and the giving of information regarding Indian

cattle or Indian dairy produce to enquirers from France, Brazil, Fiji, United States of America, West Indies, and Holland. I also assisted Dr. I. Sikijo, Principal of the Government Animal Nutrition Institute, Formosa, to select a number of Sindhi milch cows for export to Formosa on account of the Japanese Government.

IV. General.

Recognizing the value of the cinema as an educative factor, two American films illustrative of the production, treatment and transport of fresh milk for city consumption were purchased in the year under review, and they have been and will be used whenever possible in propaganda work. The films were much appreciated wherever shown and greatly simplify the work of the lecturer in describing processes unfamiliar to his hearers.

As a delegate of the Imperial Agricultural Department I attended the All-India Veterinary Conference in Calcutta in March, and took part in many of the discussions relative to cattle welfare which took place there.

I attended the annual bull sale at the military dairy farm, Ferozepur, and purchased cattle there for various Governments and private individuals, and in the year under review I purchased and despatched sixteen cows for military dairy farms, 1st Circle, and three for the Imperial Bacteriological Laboratory, Muktesar.

In January 1923, I had the honour of giving evidence before the Inchcape Committee as to the need of the country in regard to dairy education and propaganda, and concerning the proposals put forward by this office regarding the taking over of the military dairy farms by the Imperial Agricultural Department. In their report this Committee recommended that this Department should take over two farms. The Government of India have acted promptly in this matter and at the time of writing this report (1st July, 1923) this Department has actually taken over the military dairy farms at Bangalore, Wellington and Karnal, and it

is hoped to utilize these centres at a very early date as educational institutions to meet the crying need of the country in this direction. The Department owes a debt of gratitude to the Quartermaster-General in India, and to the Controller of Military Dairy Farms, at Army Headquarters, for the cordial manner in which they co-operated in connection with the transfer of these farms; not only did they agree to surrender suitable farms for our purposes, but every facility has been given by the military authorities to make the handing over of these farms easy and profitable to this department.

I submitted a paper, on the fodder needs of India from a dairy point of view, to the Indian Science Congress at Lucknow, and I have sent a paper on the importance of the development of the dairy industry in India to be read at the World's Dairy Congress at Washington, United States of America, in October 1923.

REPORT OF THE SECRETARY, SUGAR BUREAU.

(Wynne Sayer, B.A.)

Rao Saheb Kasanji D. Naik held charge of the office of the Secretary, Sugar Bureau, up to 16th November, 1922, when I returned from leave and took over charge. I held the post throughout the remainder of the year.

The Bureau continued on a temporary footing during the year under report, but sanction for further extension of the term up to 31st March, 1924, was obtained during the year. The Inchcape Committee, which was appointed with a view to examine the working of all departments under the Government of India and to make recommendations for effecting forthwith all possible reductions in the expenditure of the Central Government, reviewed the working of this Bureau, and recommended that the necessity for retaining it should be examined. The work done by the Bureau for the improvement of the sugar industry in India during the last four years of its existence has, however, been of such a substantial nature that the Indian Sugar Producers' Association, which has its headquarters at Cawnpore and which represents over 90 per cent. of the white sugar industry in India, at once addressed the Government of India expressing its keen appreciation of the valuable work done by this Bureau, and requested that it may be placed on a permanent footing. For the expansion of its useful activities and to provide the Bureau with facilities which Government are at present unable to afford on account of the financial stringency, the Association expressed its readiness to induce the industry to contribute towards its expenses, and the question of a cess on sugar produced in India has also been mooted. The large sugarcane growers of Bihar also expressed their agreement with the views of the United Sugar Producers' Association as regards the utility of the work being done by this Bureau.

It is presumed, therefore, that the Bureau will be retained by Government.

It may here be mentioned that during the year under review while Government provided Rs. 37,290 for the salaries, travelling allowances of the staff, supplies and services, and contingencies of the Bureau, the funds received from the outside public for financing work and experiments amounted to a little more than Government's contribution. It will thus be seen that the Bureau is doing work of great value to various sections of the public for which they are fully prepared to pay.

During the year under report, the Bureau continued to collect information relating to the sugar industry in all its aspects and to make it available to the public. Besides this, important work on the agricultural, commercial and industrial sides was carried out during the year. A brief resumé is given below :—

I. Agricultural.

It has been mentioned in the previous report that some 25 acres were planted with Coimbatore seedlings 210, 213, 214 and 221 in February 1922 with a view to ascertain the milling qualities of these canes under factory conditions. These canes grown without irrigation stood the hot weather remarkably well and gave a record crop of 600 maunds of stripped cane per acre of Co 214, 700 maunds of Co 210 and 800 maunds of Co 213. They were free from any serious mycological disease and unaffected by any insect pest and grew on to an absolutely first class crop in every way. Representatives of the large cane growers of Bihar who came to see the crop in November were very much struck with these canes. The agricultural side having proved a complete success, the only question that remained was to test the actual behaviour of these canes in the factory, and accordingly mill tests were arranged in

December 1922. It may be mentioned here that such mill trials are essential for ascertaining the actual value of a cane to the factory. As the analysis made in a laboratory where the juice is extracted in a 2 or 3 roller mill gives much higher results than those obtained in a mill where many other factors are to be taken into consideration, to base all calculations on the laboratory analysis alone does not meet the case. The value of a cane is its value to the grower and to the mill when grown and crushed in bulk, and figures obtained from large scale tests are the figures which really carry weight among the growers and the mills. The laboratory and experimental tests are excellent guides but do not represent final judgment in such cases.

In all these mill trials I have received most valuable assistance from the firm of Messrs. Begg Sutherland & Co. who not only advanced the money required for growing the cane for these mill trials, but have also provided funds for the testing on a large scale of the other canes. Without the generous collaboration of this firm my work would have been seriously handicapped and much valuable time lost.

The first mill tests were carried out on 6th December, 1922, when 2,444 maunds of Co 214 were supplied to the Ryam mill for crushing. This is an early ripening cane which is ready for the factory early in November when the local cane is still very immature. The yield of stripped cane per acre (*viz.*, 600 maunds) is double that of local canes. Co 214 has, however, a high fibre content of 18 per cent. which is due to its having in its parentage *Saccharum spontaneum*. It proved rather a difficult cane to handle for the mill owing to its high fibre content and its crooked habit which made it difficult to load. But by tying into bundles this difficulty has been overcome. As this cane will enable the factories to start their crushing season six

weeks earlier than usual, the results of the mill trials given below are of the greatest interest :—

Comparative analysis of first mill juice of Co 214 and Hemja.

	Co 214 crushed on 6th December	Hemja (local variety) crushed on 7th December
Brix . . .	19·30	16·70
Sucrose . . .	15·94	13·54
Purity . . .	82·58	81·08

It will thus be seen that, compared with the local cane, Co 214 yields 15 per cent. more sugar weight for weight, and its heavier yield and early ripening are additional advantages in its favour. While all the time one refers to this test it must be carefully borne in mind that in early November Co 214 would have shown itself to better advantage as the local canes then would hardly have analysed at all.

The next mill tests took place on the 18th December when over 2,000 maunds of Co 210 were put through the same mill. This cane is a heavier yielder than Co 214 and its fibre content is also lower (15·66 per cent.). It is, however, a month later in ripening and is usually ready for the factory in the first half of December. The following are the results of the mill trial :—

Analysis of the first mill juice of Co 210.

Brix	18·23
Sucrose	14·95
Purity	82·00

The last cane to be put through the mill was Co 213 which is a medium thick cane. This is essentially a grower's cane, tall, erect, free from any fungus or insect pests and yielding more heavily than the two previous canes. The average yield of this cane at Pusa amounted to 800 maunds of stripped cane per acre, while on the best

land it was as high as 1,600 maunds of unstripped cane per acre. It may be mentioned here that this cane becomes ripe by the end of December, and hence a factory working with Coimbatore canes can start early in November with Co 214, then take up Co 210, thereafter Co 213, and after the middle of January can proceed with the local Hemja which begins to ripen by then. The results of the factory analysis of the first mill juice of Co 213 crushed at Ryam on 27th December, 1922, were as under :—

Brix	17·63
Sucrose	14·52
Purity	82·86

Further details are given in the article on the mill trials of selected Coimbatore cane seedlings published in the "Agricultural Journal of India," May 1923. It will suffice to say here that the trials were a great success in establishing a cash value for the cane and providing a most important set of data by which to judge future laboratory tests on promising canes against actual mill results. It is now perfectly evident that no cane, however successful agriculturally, can be distributed to growers without first undergoing a mill trial.

If we take into account the average yield of the local varieties which does not exceed 300 maunds of stripped cane per acre while each of these Coimbatore canes yields over double the amount, it is obvious that the adoption of these canes by the growers in Bihar will considerably add to the profits of cane cultivation, while the sugar industry will get an increased supply of cane for the factories which are usually below their raw material capacity, and also enable them to prolong their working season, reducing the cost of production per maund of sugar by cutting down silent charges. And further, as these canes are grown without irrigation in the same way as the local canes in Bihar and as no trenching is required, their rapid introduction into the district is only a question of time. As soon

as the results of these mill trials became known among the large sugarcane growers of Bihar, a large demand sprang up and the balance of the canes not required for the mill trial was distributed among growers in order to get the cane grown throughout the district as quickly as possible. Over 9,000 maunds of seed cane have thus already been supplied to selected cane growers throughout North Bihar and that portion of the United Provinces which comes in the white sugar tract, *viz.*, Monghyr, Darbhanga, Muzaffarpur, Champaran, Saran and Gorakhpur districts, and from reports received from growers in all these districts, these canes have proved a success everywhere. In short, they are behaving with growers in many cases better than they did at Pusa. The hot weather this year has been very severe, the monsoon not breaking till 24th June, but these canes have stood the prolonged drought remarkably well, their stand is better and their growth more vigorous and uniform than the local canes. Already some of these growers are multiplying the seed canes supplied to them by the method of short planting, full particulars regarding which have been furnished by me for their guidance.

The demand for seed cane has been so heavy that with a view to provide seed cane in the next planting season, namely, February 1924, we further arranged to grow nearly 60 acres of these improved canes, the funds required for growing such a large area having been provided by the Bihar Sugarcane Growers' Association which is closely following the progress of these experiments and which is keen on taking up these canes for general cultivation. This crop has come on splendidly during the trying hot weather and promises to give the usual bumper crop now associated with these canes at Pusa.

These canes (Co 214, 213 and 210) have also been supplied to the Cossipore Sugar Factory, Bengal, to the Agricultural Chemist, Dacca, to the Agricultural Officer, Peshawar, to the West Indies and to Mauritius for trial.

With a view to keep up an unfailing supply of improved varieties to replace the present ones when they show signs of degeneration, I have already started testing several new seedling canes, some of which are showing signs of great promise. Varieties are also being selected with a view to their suitability for varying conditions of soil and climate in the different parts of this country.

Co 221, whose parents are J. 213 × M_2, was grown on $1\frac{3}{4}$ acres with a view to find out whether as a field crop it showed desirable characteristics. The results have shown that this cane when planted in February in the ordinary way is easily blown down by the winds and because of its soft rind is also attacked by jackals. It is further liable to red rot, and for these reasons it has been decided not to propagate it further for ordinary planting. But this cane when sown in July and early August and left till April showed none of its previous detrimental characteristics and gave a wonderful analysis of Brix 19·17, Sucrose 17·93 per cent., Glucose 0·65 per cent., Purity 93·54, showing thereby that it may be possible to plant this cane late for late crushing. Further work in this direction will now be put in hand as both the grower and the mill will benefit in this case, the former on account of the cane occupying the land for two crop seasons (*kharif* and *rabi*) only instead of the usual three, and the factory being enabled to work later on account of supplies of fully ripe cane in April-May instead of the dried up stuff it usually gets then.

Two early canes, Co 232 (J 213 × Katha) and Co 233 (J 213 × Katha), were also planted on a field scale this year. Co 232 has so far shown better germination, better vigour and more uniform growth than Co 233, and promises to give a good tonnage. It is proposed to put these canes through the mill early in December 1923, and if the mill test proves satisfactory, arrangements will be made to multiply the variety Co 232, as it is desirable to have another early ripening cane to replace Co 214 if its habit gets worse or otherwise proves unsuitable to certain localities.

As it appeared from all tests that marked vitality was one of the chief characteristics of these canes, an experiment was started to ratoon Co 214, 213, 210 and 221. The results so far show these canes as a whole to be good ratooners, the crop of Co 210 being 5 feet high before the break of the monsoon and showing great vigour throughout the hot weather. The capacity of these canes for ratooning will make a great difference to the area grown and may practically sound the death knell of the local cane over large estates.

Thirty-four new Co seedings were received during the year from the Government Sugarcane Expert and we have now under trial in the experimental area the following forty-three seedlings :—

Co 205, 227, 228, 238, 239, 240, 241, 242, 243, 244. 245, 246, 247, 248, 250, 251, 252, 253, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 273, 274, 275, 276, 277, 278, 279 and 280.

Of these, Co 227, 228, 242, 244, 257, 260, 261, 264 and 278 look most promising.

Experiments on the manuring of sugarcane have been started this year in collaboration with the Imperial Agricultural Bacteriologist as many problems in this connection require elucidation.

It has been mentioned in previous reports that nine Java varieties were brought by the Secretary, Sugar Bureau, in the year 1920 and sent to Coimbatore for trial. Unfortunately, with the exception of E. K. 28 and D. I. 52, these canes showed suspicious patches similar to those of mosaic. They have, therefore, been kept under strict surveillance till we know more about their freedom from this disease under Indian conditions. Their chief use is, however, in crossing with hardy mosaic-resistant Indian canes, and the Government Sugarcane Expert has made extensive use of P. O. J. 1410 and P. O. J. 1499 in this direction. Already over 10,000 seedlings have been obtained by crossing in this manner.

II. Industrial.

The Bureau continued to be in touch with sugar factories in India. Returns for the working season 1921-22 were received and statistics regarding the production of refined sugar in India have been compiled. During the year under report, the Nira Valley Sugar Factory began working at Baramati in the Bombay Presidency. This is the first factory at present working in that presidency, while another, the Belapur Sugar Factory, is expected to be in working order next year. In the Madras Presidency a company was floated in the Tinnevelly District for the production of refined sugar from palm *gur*, and another has been projected in Travancore State. But the greatest signs of activity are in Bihar and the United Provinces where the prospects for the industry are favourable. In Bihar a factory is being erected at Pachrukhi near Sivan, and another *gur* refinery is adding on the plant for manufacturing sugar direct from cane. There are several other projects which are still in the preliminary stage, the general stringency in the money market handicapping them in several respects. Against these, must be set down the closing of two concerns; but it is nevertheless true that the Indian sugar industry aided by an import duty of 25 per cent. and general rise in the value of sugar is trying to put its house in order by organization and improvement in manufacturing efficiency, and it is most encouraging to note that Messrs. Begg Sutherland & Co., who manage seven sugar factories in Bihar and the United Provinces, have recruited the well-known authority Mr. Noel Deerr as their chief Chemist and Technologist. This will furnish an object lesson to other factories as to the necessity of providing sound and efficient scientific supervision and control over sugar production. I wish here to express my obligations to Mr. Noel Deerr for the valuable assistance he has given me on all technical questions which I have referred to him.

The Bureau kept in touch with sugar machinery manufacturers in Great Britain and the United States of America, and the correspondents who seek the advice of this office were kept informed of the reductions in the price of sugar machinery that took place during the year.

The small 4-roller power-driven mill sent out by the Honolulu Iron Works referred to in the last report was sent to the Agricultural Chemist at Dacca for trial in October 1922. It was not possible to arrange for thorough trials during the season, but it is hoped to make extensive trials this season with Yellow Tanna and Co 213. It will then be possible to say whether the mill can be recommended to cultivators.

The Bureau continued to help sugar factories by bringing before them the names of suitable persons seeking employment as works chemists or managers, agricultural superintendents for sugar estates, etc. Applications are received from persons not only in India but from those in other cane growing countries of the world, and the Bureau is serving as a good link between the employers and those seeking employment.

III. Commercial.

The Bureau continued to assist the sugar trade in India by publishing, in the "Indian Trade Journal," statistical notes bearing on the production and consumption of this commodity in the principal sugar producing countries of the world and the rise and fall in the world's price of sugar. Seventy such notes were published during the year.

The sugar cable service started with the approval of the Government of India in January 1922 was continued during the whole year under report. It is an all-India service, having members in Bombay, Madras, Calcutta, Cawnpore, Lyallpur and Karachi, and influential Hindu, Mohammadan, Parsi, European and Japanese sugar firms have joined it.

The service is conducted on a self-supporting basis, all expenses being met from the subscriptions of the members. While this service costs nothing to Government, it is indirectly a source of revenue to them inasmuch as the Post and Telegraph Department benefit to the extent of Rs. 16,000 extra business.

The cable service has proved of the greatest value in stabilizing the sugar markets in India by preventing any panic or sudden rise due to unofficial reports and rumours from foreign countries. This has resulted in the price of sugar in India being kept in agreement with world parity as expressed in New York, and has effectually prevented ignorant speculation and its woeful results. The year under report has been marked by several attempts to rig the market in New York and Cuba into a condition when all losses sustained in the past could be recouped from the general public. This movement naturally had its effect on prices in Java and India. By enabling Indian buyers to keep in close touch with New York prices, any undue inflation of prices has been checked and a steady rise or fall in consonance with the world supply and demand has resulted, giving the consumer the full benefit and at the same time protecting the forward buyer who no longer acts in ignorance of world's conditions as was frequently the case in the past.

IV. Miscellaneous.

Library. During the year under report, 229 volumes were added to the library either by purchase, exchange or free supply. A catalogue of books and periodicals was issued and copies were distributed to all the Directors of Agriculture and Industries in the provinces, special workers in the sugar line and institutions where such catalogues are likely to be required for reference. Books continued to be issued from the Library on loan to approved persons.

Museum. During the year under report, special samples of Java sugar were received through the courtesy

of the Java Sugar Experiment Station at Semarang. Samples of various grades of sugar manufactured in the Philippine Islands were also received through the kindness of the Director of Agriculture of those islands. These have been placed in the museum. As usual, all samples of sugar made in Indian factories were renewed during the year.

Publications. Besides the 70 notes contributed to the "Indian Trade Journal" mentioned above, 8 notes were contributed to the "Agricultural Journal of India," and the following two articles were published during the year:—

Naik, K. D. . . A Review of the Sugar Trade in India during the calendar year 1921. Supplement to *The Indian Trade Journal*, dated 21st September, 1922.

Sayer, W. . . Mill Trials of Selected Coimbatore Sugarcane Seedlings. *Agricultural Journal of India*, May, 1923.

V. Conclusion.

During the four years of its existence the Sugar Bureau has made its activities known to the sugarcane growers, sugar manufacturers and sugar importers and dealers, and they are showing their appreciation of the work done by coming forward to finance the activities which are of direct benefit to them, so much so that when it was rumoured that the activities of the Bureau might either be curtailed or stopped altogether, representative organizations of the growers and manufacturers lost no time in coming forward to show Government what value they attached to the Bureau's activities. It is a great pity that, in the present financial stringency, it is difficult for the Government to provide additional grants for the expansion of the Bureau's activities, but it is hoped that the industry which now realizes that its future welfare is bound up with the activities of this Bureau to a considerable extent will do its

share and give a further impetus to research and other work on cane.

In conclusion, I wish to express my acknowledgments to the Director-General of Commercial Intelligence, Calcutta, for the invaluable help and ready advice given in connection with the sugar cable service and other trade matters, to the Imperial Agriculturist, Mr. Henderson (I am not thanking myself), without whose co-operation it would have been impossible to carry out the large scale experiments at Pusa, to the Imperial Agricultural Chemist for ready assistance given in analysing sugarcane samples sent to him from time to time, to the Government Sugarcane Expert for the assistance cheerfully rendered by him on all occasions, and lastly to Mr. Noel Deerr and Mr. J. T. J. Crooks for advice on various technical matters referred to them. With the assistance of such a distinguished company I feel sure we are doing all in our power to command success.

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